UNCLASSIFIED

AD NUMBER

AD800973

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution authorized to DoD only; Administrative/Operational Use; AUG 1966. Other requests shall be referred to Commanding General, Hq., US Army Materiel Command, Attn: AMCRD-D, Washington, DC.

AUTHORITY

Army Aviation Systems Command ltr dtd 12 Nov 1973

THIS PAGE IS UNCLASSIFIED

800973

AD______________

RTD&E PROJECT NO. F1F131201D161
USATECOM PROJECT NO. 4-5-1220-01
USAAVNTA PROJECT NO. 62-72

PART 1 OF 2 PARTS

ENGINEERING FLIGHT RESEARCH EVALUATION OF THE XV-5A LIFT-FAN AIRCRAFT

PART 1 - STABILITY AND CONTROL

FINAL REPORT

BY

RODGER L. FINNESTEAD
AND
KENNETH R. FERRELL
PROJECT ENGINEERS

WILLIAM L. WELTER
MAJOR, U.S. ARMY, TC
AND
WILLIAM A. ANDERSON
PROJECT PILOTS

AUGUST 1966

U.S. ARMY AVIATION TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA

COPY___OF___

SAVFE-AA (29 Sep 1966) 1st Ind
SUBJECT: Proposed Engineering Test Report "Engineering Flight Research Evaluation of the XV-5A Lift Fan Aircraft, Part I, Stability and Control", RDT&E Project No. 1F131201D161, USATECOM Project No. 4·5·1220·01(U)

HEADQUARTERS, US ARMY AVIATION MATERIEL LABORATORIES, Fort Eustis, Virginia, 23604

TO: Commanding Officer, US Army Aviation Test Activity, ATTN: STEAV-PO, Edwards Air Force Base, California, 93523

1. Subject document is approved for distribution.

2. The following printing errors were noted in the Final Report and should be corrected by an errata sheet.

a. Page 54, paragraph 2.2.3.4.1.3., reference to Figure B, should be changed to Figure C.

b. Page 56, Figure C, d_{S_R}/dB should be d_{F_R}/dB.

c. Page 103, paragraph 2.4.2.4.3., 32 KCAS, should be 42 KCAS. Reference, Figure 130.

d. Page 107, paragraph 21, line 12, 3.5 degrees should be 16.5°. Reference, Figure 133.

2 Incl
wd

/S/ Harry L. Bush
HARRY L. BUSH
Colonel, ARTY
Commanding

RDT&E PROJECT NO. F1F131201D161
USATECOM PROJECT NO. 4-5-1220-01
USAAVNTA PROJECT NO. 62-72

PART 1 OF 2 PARTS

ENGINEERING FLIGHT RESEARCH EVALUATION OF THE XV-5A LIFT-FAN AIRCRAFT

PART 1 - STABILITY AND CONTROL

TEST REPORT

BY

RODGER L. FINNESTEAD
AND
KENNETH R. FERRELL
PROJECT ENGINEERS

WILLIAM L. WELTER
MAJOR, U.S. ARMY, TC
AND
WILLIAM A. ANDERSON
PROJECT PILOTS

U.S. ARMY AVIATION TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA

TABLE OF CONTENTS

ABSTRACT

An engineering flight research evaluation was conducted to investigate the flying qualities and stability and control characteristics of the research model XV-5A lift-fan vertical and short takeoff and landing (V/STOL) aircraft. The flight evaluation was conducted at Edwards Air Force Base, California, by the U. S. Army Aviation Test Activity, under the technical cognizance of the U. S. Army Aviation Materiel Laboratories. Testing consisted of 24.2 productive flight hours and was conducted from 28 January through 30 June 1965. The flying qualities of the XV-5A observed during this evaluation were suitable for accomplishment of its primary mission as a research aircraft. Test results indicated an excellent stability augmentation system and good compatibility between fan-mode and jet-mode control systems. Poor flying qualities were encountered while hovering below a wheel height of 10 feet. Six characteristics were observed for which correction was considered to be mandatory for any follow-on XV-5 aircraft. Correction of twelve additional characteristics was considered to be desirable for follow-on XV-5 aircraft. Nine areas were recommended for consideration during any further development of this configuration and/or concept. An overall pilot opinion of 4 was assigned to the flying qualities of the XV-5A aircraft observed during this evaluation.

FOREWORD

1. <u>AUTHORITY</u>

Letter, AMSTE-BG, Hq, U. S. Army Test and Evaluation Command (USATECOM), 12 March 1965, subject: "Test Directive for Military Potential Test of the Lift-Fan Propulsion System Concept Installed in the XV-5A Aircraft, USATECOM Project Task No. 4-5-1220-01."

2. <u>REFERENCES</u>

A list of references is contained in Section 3, Appendix IX.

3. <u>REPORT PUBLICATION</u>

The results of the "Engineering Flight Research Evaluation of the XV-5A Lift-Fan Aircraft" will be published in two parts. Part I, consisting of the Stability and Control evaluation, is presented in this report. Part II, consisting of the Performance evaluation, is expected to be published in the latter part of 1966.

◀ **Photo 1- XV-5A Lift Fan At Hover**

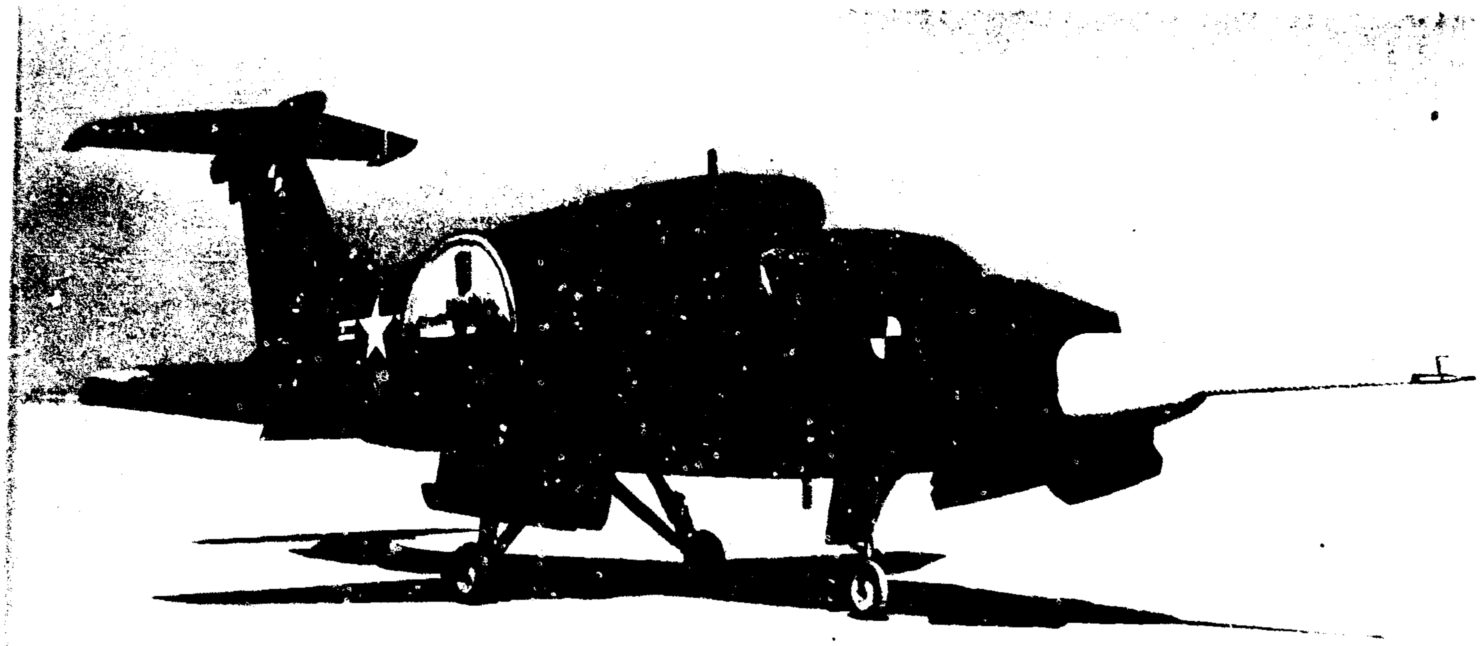


Photo 2- XV-5A In Fan Mode Configuration

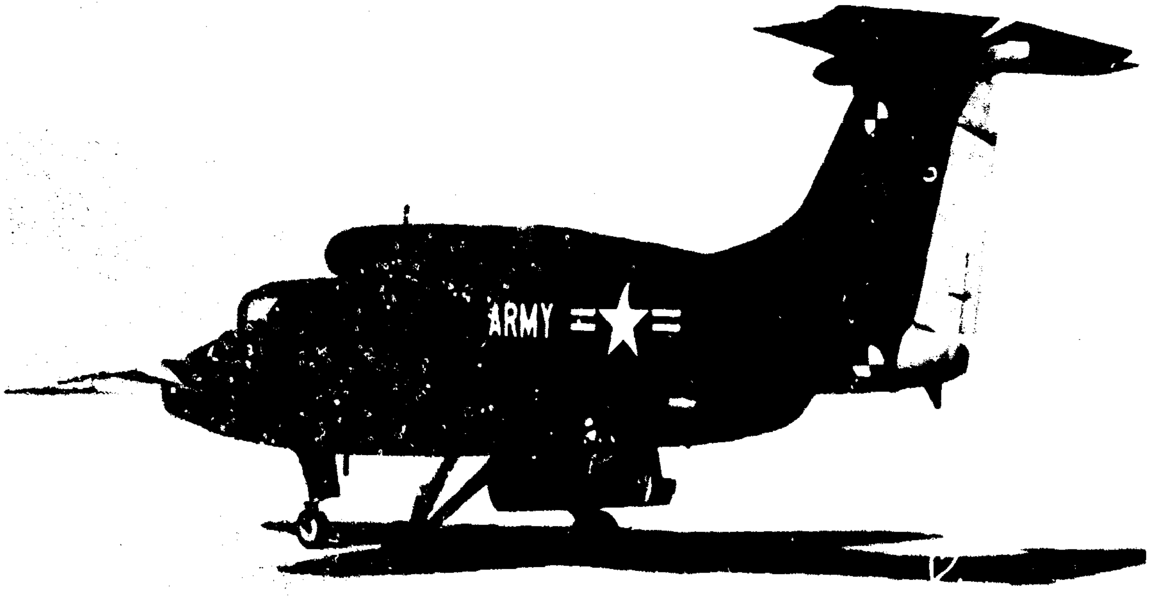


Photo 3- XV-5A In Jet Mode Configuration

SECTION 1 - GENERAL

1.1 OBJECTIVE

To conduct flight investigations to obtain stability and control criteria applicable to future Army developmental aircraft using the XV-5A configuration and/or concept.

1.2 RESPONSIBILITIES

The U. S. Army Aviation Materiel Laboratories (USAAVNMLABS) had technical control and cognizance of the overall program and provided an on-site Program Manager's representative.

The U. S. Army Aviation Test Activity (USAAVNTA) had responsibility for conduct of the test program as outlined in Paragraph 1.1. This included preparation and coordination of the plan of test with USAAVNMLABS, coordination of test execution and preparation of required test reports.

USAAVNMLABS negotiated a contract that required the commercial contractor to furnish support (maintenance, logistics, and facilities) for this test program (Reference b, Section 3, Appendix IX).

An organizational chart and detailed description of responsibilities are presented in Appendix VIII.

1.3 DESCRIPTION OF MATERIEL

The XV-5A (former military designation VZ-11) is a mid-wing, tri-fan, turbojet-powered research aircraft. The total aircraft assembly has a maximum gross weight of 12,500 pounds. The crew stations consist of a single cockpit with side-by-side seating for a pilot and an observer. In the conventional takeoff and landing (CTOL) flight mode, thrust is supplied by two J-85-5B turbojet engines. In the vertical takeoff and landing (VTOL) and short takeoff and landing (STOL) flight modes, engine thrust is diverted to drive two wing fans designated as the X353-5B system and a single nose-mounted pitch-control fan designated as the X376 system.

The XV-5A aircraft has two basic primary flight control systems: the fan-powered control system and the conventional control system. Except for the lift control (collective stick) of the fan-powered system, both control systems are operated from common cockpit controls and linkage to common junctures within the fuselage. From these control junctures the linkage is branched off as required to serve either fan-powered or conventional system functions.

The conventional surfaces (elevator, rudder, and ailerons) are operable at all times; the fan-powered output controls are electro-mechanically made ineffective during transition to conventional flight.

A detailed description of the XV-5A aircraft systems is presented in Appendix III.

1.4 BACKGROUND

USAAVNMLABS was assigned the overall program responsibility for a lift-fan research program divided into two phases: Phase I (Reference a), consisting of design, fabrication, and 50 hours of flight testing of two XV-5A aircraft by the contractor; and Phase II (References b, c, and d), consisting of 100 hours of flight testing by the U. S. Government.

Specific objectives of Phase I were to determine and evaluate the flight characteristics of the lift-fan in hover and transition regime and to evaluate, by high-speed flight of the research VTOL aircraft, the compatibility of the lift-fan propulsion system with a high subsonic speed aircraft configuration. This phase was completed on 26 January 1965. The two XV-5A aircraft were delivered to the Army for further flight testing on 28 January 1965.

A Test Directive defining objectives and responsibilities for Phase II was issued by USATECOM 12 March 1965. The responsibilities for this flight research program for USAAVNMLABS and USAAVNTA were as stated in Paragraph 1.2 and Appendix VIII. A test plan (Reference f) was submitted by USAAVNTA for coordination by USAAVNMLABS in December 1964.

The stability and control flight research testing consisted of 24.2 productive flight hours and was conducted at Edwards Air Force Base, California, from 28 January 1965 to 30 June 1965.

USAAVNTA submitted Letter Report of Preliminary Pilot Qualitative Evaluation of the XV-5A Research Aircraft to USAAVNMLABS on 28 October 1965 (Reference g).

1.5 FINDINGS

1.5.1 COCKPIT, FLIGHT CONTROL SYSTEMS AND GROUND HANDLING CHARACTERISTICS

1.5.1.1 Cockpit

The cockpit area was large and provided the pilot with ample space. Inflight cockpit temperature control was unsatis-

factory. Ventilation was achieved by small vents along the canopy periphery. These vents were inadequate cooling devices at lower altitudes and, due to the pilot's inability to close them, unsatisfactory during high-altitude flights. Switches and controls were within easy reach of the pilot except for the oxygen diluter valve and quantity gage which should be repositioned. Other cockpit switch and instrument location changes should be made. Fields of view forward and sideward were good. During hover operations, downward vision was restricted. In addition, the canopy release mechanism provided no satisfactory "vent" position for use during ground operations. No positive canopy lock indication was available to the pilot. Paragraphs 2.1.1.4.1, .2, .3, .4.

1.5.1.2 Cockpit Warning Systems

Activation of the fan-overspeed warning system served no useful purpose during this evaluation. Flights in fan-mode (FM) configuration at airspeeds greater than 60 knots calibrated airspeed (KCAS) were generally conducted with the fan-overspeed warning system activated. The warning system should be activated only when automatic power cutback occurs. After power reset procedures have been satisfactorily completed, the fan-overspeed warning system should be automatically deactivated with no pilot action required. Additional modifications to the fire warning system, annunciator panel, and master caution light are required to improve respective system effectiveness. Paragraphs 2.1.1.4.5.2.1, .2, .3.

1.5.1.3 Flight Control Systems

Control breakout forces and force gradients were qualitatively observed to be satisfactory about all axes in both jet-mode (JM) and FM configurations. Poor correlation between flight and ground test control system data was observed. In FM configuration during low-speed translational maneuvering, the lateral and longitudinal control stick forces were too high, thereby increasing pilot fatigue. In JM configuration, the lateral control stick forces were too low and contributed to pilot-induced lateral oscillations. No objectionable control system characteristics were noted during aircraft conversions between JM and FM configurations. A pilot opinion rating of 3 (see Appendix VII) was assigned to the observed characteristics of the flight control systems. Paragraph 2.1.2.5.

1.5.1.4 Ground Handling Characteristics

The light-duty brakes and narrow main gear track (8.39 feet, wheel to wheel) caused prolonged taxiing to be precarious. The use of thrust spoilers to reduce residual thrust as an additional braking technique did not satisfactorily alleviate this problem.

These characteristics were assigned a pilot opinion rating of 5. Paragraph 2.1.2.6.

1.5.2 FAN-MODE STABILITY AND CONTROL

1.5.2.1 Static Trim Stability

The static longitudinal trim stability was negative at airspeeds greater than approximately 50 KCAS and positive for airspeeds below 50 KCAS. The stick-position reversal was gradual with no sharp discontinuities. The longitudinal trim system provided insufficient nose-down trim authority between 32 KCAS and 72 KCAS. The lateral trim stability was nonlinear with airspeed due to the unsymmetrical phase-out of differential stagger with vector angle. The directional trim requirement was linear as a function of airspeed with increasing left pedal required as airspeed increased. The pedal trim forces varied from 7 pounds right pedal to 6 pounds left pedal in hover at an airspeed of 87.5 KCAS. These findings were considered to be satisfactory; however, the insufficient forward longitudinal trim authority was undesirable and should be corrected. A pilot opinion rating of 3.5 was assigned to the static trim stability characteristics in FM configuration. Paragraphs 2.2.1.4.1.2, .3, 2.2.1.4.2.2, 2.2.1.4.3.2, .3, 2.2.1.5.

1.5.2.2 Static Longitudinal Stability

Negative stick-fixed and stick-free static longitudinal stability existed at airspeeds greater than 50 KCAS, reaching a maximum negative value at 74 KCAS. Due to the insufficient longitudinal trim authority in this region, "stick feel" was not the prominent factor to the pilot for airspeed control during fan-powered flight. The negative stability characteristics did, however, contribute to the requirement for careful pilot technique during any aircraft configuration changes within this flight regime, i.e., climbs and descents, speed and power. A pilot opinion rating of 3.5 was assigned to the static longitudinal stability characteristics in FM configuration. Paragraphs 2.2.2.4.1.2, .3, 2.2.2.5.1.

1.5.2.3 Static Directional Stability and Effective Dihedral

The pedal-fixed directional stability was positive, varying in magnitude directly with airspeed, for all airspeeds tested. The pedal-free directional stability was positive for all airspeeds with a minimum value observed at 45 KCAS. The stick-fixed and stick-free effective dihedrals were positive and nonlinear as airspeed was varied from 30 KCAS to 74 KCAS. During steady-heading

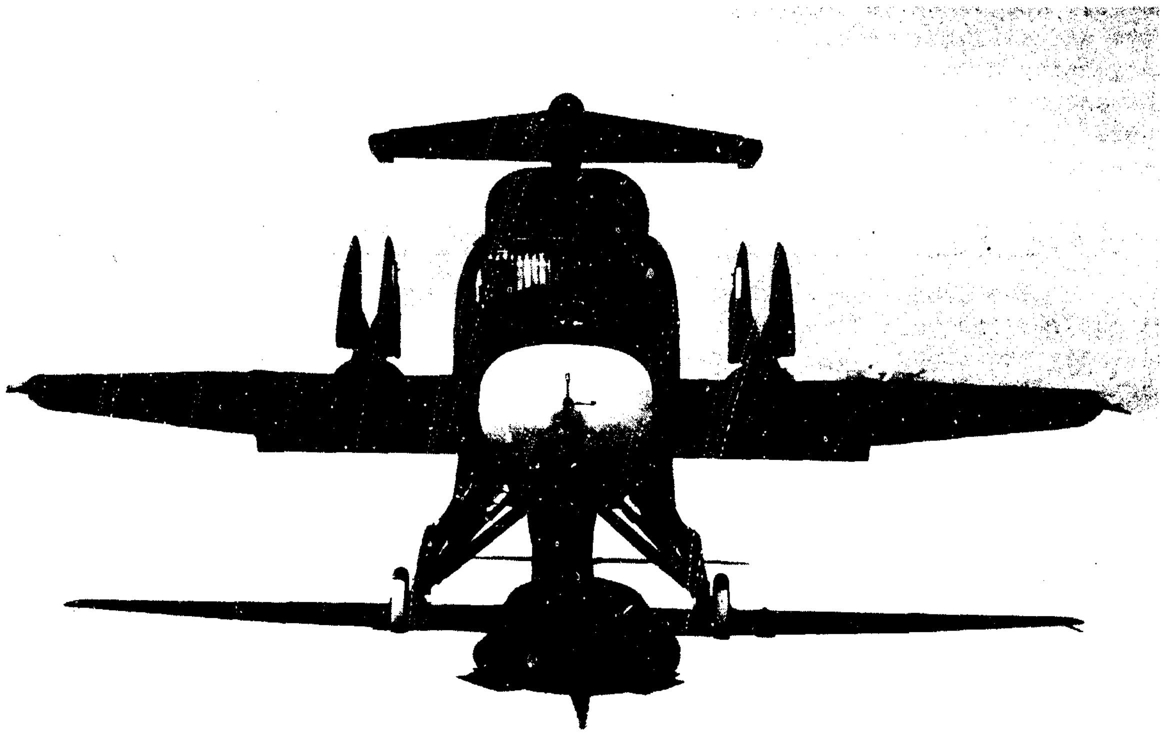


Photo 4- XV-5A In Fan-Mode Configuration

sideslips, directional control inputs were characterized by light forces at airspeeds between 30 KCAS and 60 KCAS. At these airspeeds, the aircraft tended to yaw indiscriminately about the desired sideslip angles, becoming more prominent as airspeed was reduced below 60 KCAS. This result was more of a nuisance than an objectionable characteristic in the accomplishment of the primary research mission. A pilot opinion rating of 3 was assigned to the static directional stability characteristics and effective dihedral observed in FM configuration. Paragraphs 2.2.3.4.1.2, .3, 2.2.3.4.2.2, .3, 2.2.3.5.1.

1.5.2.4 Static Stability During Sideward Flight

The directional control requirement during sideward flight was nonlinear with control reversals occurring during lateral translations both to the right and to the left. From trimmed hover to approximately 11.5 knots, the directional trim stability was nonlinear and negative with right pedal required for right lateral translation and left pedal required for left lateral translation. A reversal occurred in the directional control requirement at a speed of approximately 11.5 knots and the stability was positive

for all speeds up to 24.5 KCAS. The lateral trim stability was positive and slightly nonlinear over the speed range investigated. An increasing nose-up longitudinal pitching moment was encountered as the speed was increased in either direction. A pilot opinion rating of 3.5 was assigned to the sideward flight characteristics. Paragraphs 2.2.4.4.1.2, .3, .4, 2.2.4.5.1.

1.5.2.5 Static Stability During Low Speed Forward and Rearward Flight.

The longitudinal trim stability during low-speed forward flight and rearward flight (18 KCAS maximum) was positive and slightly nonlinear. The lateral and directional control requirements during these flight conditions were small. A pilot opinion rating of 2.5 was assigned to these observed characteristics. Paragraphs 2.2.4.4.2.2, .3, 2.2.4.5.1

1.5.2.6 Dynamic Longitudinal Stability (SAS On)

The dynamic longitudinal stability characteristics were similar at all airspeeds tested. Any existing variations in stability characteristics with airspeed were masked by strong SAS damping. Typically there was a small characteristic overshoot with no residual oscillations. Qualitatively the observed longitudinal disturbances were well damped over the entire fan-mode airspeed envelope. A pilot opinion rating of 2 was assigned to these characteristics. Paragraphs 2.2.5.4.2, 2.2.5.5.1.

1.5.2.7 Dynamic Lateral-Directional Stability (SAS On)

A lateral disturbance resulted in a highly damped lateral oscillation for all airspeeds below 74 KCAS. This high degree of damping was attributed to the SAS. Qualitatively no coupling of lateral-directional oscillations existed as a result of pulse disturbances of the lateral or directional controls in hovering flight. At airspeeds above 30 knots, directional gust sensitivity was high and resulted in considerable positive lateral coupling, even in light turbulence. A pilot opinion rating of 3.5 was assigned to the lateral-directional stability characteristics in FM configuration. Paragraphs 2.2.5.4.3, 2.2.5.5.1.

1.5.2.8 Dynamic Directional Stability (SAS On)

The dynamic directional stability was positive in a hover. The aircraft yawed in the direction of the disturbance, then stabilized at some new heading. Paragraph 2.2.5.4.4.

The dynamic directional stability was positive in level flight with the SAS providing very high damping at airspeeds be-

tween 30 and 49 KCAS. At 52 KCAS the motion was a lightly damped, complementary roll and yaw oscillation with a period of approximately 3 seconds. The weak stability was caused by reduced SAS effectiveness and lack of aerodynamic damping. As airspeed was increased to 70 KCAS the stability improved. A pilot opinion rating of 3 was assigned to these characteristics. Paragraph 2.2.5.5.3.

1.5.2.9 Controllability (SAS On)

1.5.2.9.1 Longitudinal Controllability

The longitudinal control sensitivity varied nonlinearily with airspeed. The control sensitivity during a hover at 30-percent collective was 6.0 deg/sec^2/inch and increased to 7.6 deg/sec^2/inch for a collective setting of 70 percent. The longitudinal sensitivity at 43 KCAS was 5.0 deg/sec^2/inch and 6.0 deg/sec^2/inch for an aft and a forward input respectively. The maximum angular acceleration per inch of stick then increased nonlinearily with speed and reached14.6deg/sec^2 for a forward input, and 13 deg/sec^2 for an aft control motion at an airspeed of 70 KCAS. The time required to reach the maximum was approximately .35 seconds. Paragraph 2.2.6.4.1.2.

The longitudinal control response in a hover was the same for both a 30-percent and 70-percent collective setting. The magnitude of this response was 2.4 deg/sec/inch. In level flight, the control response was essentially the same from 43 KCAS to 70 KCAS. The magnitude for a forward step was 3.0 deg/sec/inch and 2.4 deg/sec/inch for an aft input. The time required to reach maximum rate was .7 seconds. Paragraph 2.2.6.4.1.3.

The angular pitch displacement (deg/inch) was basically the same for hover and level flight. In all cases the longitudinal control input caused a pitch attitude change in the proper direction. The pitch displacement in a hover for 30-and 70-percent collective control was 2 deg/inch at 1.0 second after control input. The angular pitch displacement between 43 and 70 KCAS was a constant 2.3 deg/inch for a forward input and 1.7 deg/inch for an aft step at 1.0 second after control input. Paragraph 2.2.6.4.1.4.

1.5.2.9.2 Lateral Controllability

The lateral control sensitivity in a hover varied with collective stick position. The sensitivity in a hover was 12 deg/sec^2/inch at 30-percent collective control and 17.7 deg/sec^2/inch for a collective setting of 70 percent. The maximum control sensitivity in level flight occurred at 30 KCAS with a value of 18 deg/sec^2/inch. The angular acceleration then decreased with airspeed

and reached a minimum sensitivity of 15 deg/sec^2/inch at 58 KCAS. Above 58 KCAS, the sensitivity then increased slightly to a value of 15.8 deg/sec^2/inch at 70 KCAS. The maximum acceleration for a lateral step control input was reached in .4 seconds during hover and .35 seconds in level flight. Paragraph 2.2.6.4.2.2.

The lateral control response during a hover was 4.0 deg/sec/inch, and a 70-percent collective setting produced 5.8 deg/sec/inch. The control response for level flight at 30 KCAS was 6.5 deg/sec/inch and decreased slightly to 6.0 deg/sec/inch as airspeed was increased to 60 KCAS. As airspeed was further increased to 70 KCAS, the maximum roll rate per inch of stick increased to 6.4 deg/second. The time required to reach this maximum roll rate was approximately 1.0 second. Paragraph 2.2.6.4.2.3.

The roll displacement during a hover varied with collective control position. For a collective position of 30 percent, the bank angle was 1.7 deg/inch and, for a collective position of 70 percent, the roll displacement increased to 3.0 deg/inch. At an airspeed of 30 KCAS, the angular roll displacement was 2.8 deg/inch and increased slightly to 3.3 deg/inch at an airspeed of 70 KCAS. Paragraph 2.2.6.4.2.4.

1.5.2.9.3 Directional Controllability

The magnitude of the directional control sensitivity in a hover varied from 6 deg/sec^2/inch to 7 deg/sec^2/inch for a collective setting of 30 and 70 percent respectively. The minimum sensitivity during level flight was 8 deg/sec^2/inch at 30 KCAS. The angular acceleration then increased nonlinearly with airspeed to 11.0 deg/sec^2 at an airspeed of 70 KCAS. The time required to reach maximum angular acceleration in level flight was .45 seconds. Paragraph 2.2.6.4.3.2.

The angular velocity in a hover varied with collective control position. By increasing the collective from 30 to 70 percent, the maximum rate varied from 3.5 deg/sec/inch to 5.8 deg/sec/inch respectively. Although the pedal input was held for approximately 3 to 6 seconds, the yaw rate continued to increase with the maximum not occurring before recovery action was necessary. The time required to obtain the maximum yaw rate in level flight varied from 1.4 seconds at 30 KCAS to .85 seconds between 55 and 70 KCAS. The maximum control response was 4.7 deg/sec/inch at an airspeed of 30 KCAS. The directional control response then decreased to a value of 3.0 deg/sec/inch at 70 KCAS. Paragraph 2.2.6.4.3.3.

These values of sensitivity and response, similar to those of the H-43B, were low by normal helicopter standards. In-

creased directional control power should be provided for operational flight conditions of winds and turbulence.

1.5.2.9.4 Pilot Controllability Comments

During test condition hover operations above 10-foot wheel height with SAS at test settings and collective stick less than 75 percent, the controllability characteristics about the 3 axes were excellent. Results of dynamic disturbances showed the SAS to be a very effective system. During hover operations below 10 feet, an evaluation of controllability characteristics was not possible due to the problem area discussed in Paragraph 1.5.4.1. Although not quantitatively documented, there existed a severe degradation of lateral fan-mode control power with application of full-up (100-percent) collective stick. This collective position-lateral control coupling characteristic was unsatisfactory and required correction. The controllability characteristics about the 3 axes observed for the 30 KIAS-80 KIAS airspeed range enhanced the flying qualities of the XV-5A. An overall pilot opinion rating of 3 was assigned to the fan-mode controllability characteristics. Paragraph 2.2.6.5.

1.5.2.10 Airspeed Calibration

The nose-boom (low-airspeed) system indicated low for all airspeeds between 30 and 85 KIAS. This position error was constant, with a value of 3 knots, for an angle-of-attack range of -2 to +5 degrees. Paragraph 2.2.7.4.

The wing-boom (high-airspeed) system was not reliable at airspeeds below 80 KIAS. This system, therefore, was not calibrated for fan-mode flight. Paragraph 2.2.7.4.

1.5.3 JET-MODE STABILITY AND CONTROL

1.5.3.1 Longitudinal Trim Changes

The longitudinal stick force trim changes caused by variations in flap setting and fan configuration exceeded 10 pounds in most cases. The magnitude and rate of trim change, however, were easily trimmed by use of the horizontal stabilizer. No measurable lateral or directional coupling was encountered during any of the longitudinal trim change tests. A pilot opinion of 3 was assigned to these characteristics. Paragraphs 2.3.1.4, 2.3.1.5.

1.5.3.2 Longitudinal Trim Stability

The static longitudinal trim stability was positive for

an airspeed range of 102 to 330 KCAS and sufficient trim was available to maintain zero stick forces. For this airspeed range, the horizontal stabilizer position varied from 2.7 to .5 degrees leading edge down. The trim stability was neutral for the full-flaps-down gear-up configuration. The longitudinal trim stability in the pre-conversion configuration was similar to that in the full-flaps-down gear-up configuration at an airspeed of 100 KCAS. Paragraph 2.3.2.4.1.

During this evaluation, two trim rates were evaluated in jet-mode flight. The .2-deg/second horizontal stabilizer trim rate was too slow at airspeeds less than 150 KIAS. The .4-deg/second trim rate evaluated during the early portion of the evaluation was too fast at airspeeds in excess of 250 KIAS. A pilot opinion rating of 4 was assigned to the jet-mode longitudinal trimmability characteristics. Paragraph 2.3.2.5.2.

Photo 5- XV-5A In Jet-Mode Configuration

1.5.3.3 Static Longitudinal Stability

The static longitudinal stability, stick-fixed and stick-free, was positive for the conditions tested. Shallow positive stick force gradients and large trim bands about the trim airspeeds described typical static longitudinal stability characteristics in Pre-Conversion (PC) and Cruise (CR) configurations. These characteris-

tics, more pronounced in PC configuration, were not objectionable and provided satisfactory speed control for "smooth air" test conditions. Any further testing of this nature should include similar tests conducted in turbulent flight conditions. The reversible longitudinal control system was not objectionable for airspeeds less than 250 KIAS; however, above this airspeed the high stick-free longitudinal stability was disconcerting. A pilot opinion rating of 3 was assigned to the jet-mode static longitudinal stability characteristics. Paragraphs 2.3.2.4.2, 2.3.2.5.1.

1.5.3.4 Static Directional Stability and Effective Dihedral

The pedal-fixed static directional stability characteristics were positive (right pedal required for right yaw) for all conditions tested. The pedal-fixed directional stability became more positive and was slightly nonlinear as airspeed was increased from 133 KCAS to 325 KCAS. In PC configuration, the pedal-fixed stability was nonlinear with airspeed and the maximum positive stability was at 122 KCAS. The stability then decreased with airspeed and appeared to be positive for airspeeds up to the maximum PC speed limit. There was no change in the stability with the gear position. The pedal-free stability was positive and linear for all conditions tested. Paragraphs 2.3.3.4.1.1, .2.

The stick-fixed dihedral effect was positive and nonlinear for all conditions tested. The magnitude of the stick-fixed stability gradient in CR configuration was essentially the same for an airspeed range from 133 KCAS to 325 KCAS. The stability became more positive when the flaps were lowered to the full-down position. Paragraph 2.3.3.4.2.1.

The stick-free dihedral effect was slightly positive to neutral for CR configuration. The stability was negative with full-down flaps at an airspeed of 150 KCAS. In PC configuration, the stick-free stability was positive at 102 KCAS and decreased with inincreased airspeed and became neutral at 124 KCAS. The stability in this configuration was negative at higher speeds. Paragraph 2.3.3.4.2.2.

In PC configuration at airspeeds less then 110 KIAS, there existed a distracting tendency for the aircraft to wander in yaw (±2 degrees maximum). At airspeeds greater than 110 KIAS, the static directional stability increased in both PC and CR configurations. In PC configuration at airspeeds greater than 140 KIAS, the aircraft tended to oscillate laterally after a gust disturbance. Based on these undesirable characteristics, the full-flap extension limit speed should be reduced from 180 KIAS to 140 KIAS. A pilot opinion rating of 3 was assigned to the static lateral-directional stability characteristics. Paragraph 2.3.3.5.

1.5.3.5 Stall Characteristics

Data from a limited contractor stall investigation indicated that an aerodynamic stall was reached before a minimum control speed occurred. Stability, both stick-fixed and stick-free, was linear from the trim condition down to the actual stall. At the stall, the longitudinal control forces decreased, the aircraft pitched down, then rolled approximately 30 to 40 degrees. The roll was usually to the left but in some cases was to the right. A yawing oscillation accompanied the roll and pitch at the stall. Paragraph 2.3.4.4.

During the contractor-conducted investigation an undesirable post-stall gyration was encountered. Future investigations should be conducted in this area to include the determination of the effectiveness of power reduction as a power-on stall recovery technique. Paragraph 2.3.4.5.

1.5.3.6 Asymmetric Power

Adequate lateral control and directional control were available to control the aircraft at airspeeds above the minimum airspeed tested (120 KCAS) with the gear up and a flap setting of 25 percent with one engine at idle power setting. The resulting change in directional control and force to maintain zero sideslip was .3 inches left and 20 pounds left as airspeed was varied from 160 to 120 KCAS. No objectionable flying qualities were encountered during these limited tests. A pilot opinion rating of 2 was assigned to the observed jet-mode asymmetric power flying qualities. Paragraphs 2.3.5.4, 2.3.5.5.

1.5.3.7 Dynamic Stability

The short-period dynamic longitudinal stability was positive and heavily damped in CR configuration. All rates and accelerations were in the proper direction and were essentially damped to zero in one cycle. Paragraph 2.3.6.4.

In PC configuration, lateral disturbances were lightly damped and resulted in a bank angle's being established in the direction of the control input.

A pilot opinion rating of 2.5 was assigned to the jet-mode dynamic longitudinal stability characteristics. Paragraphs 2.3.6.4, 2.3.6.5.

1.5.3.8 Airspeed Calibration

The nose-boom (low-airspeed) system position error was nonlinear for all configurations and varied in magnitude from a minimum of -4.5 knots to a maximum of +9.0 knots. For CR configuration, the position error varied from a value of -4.5 knots at 103 KIAS to +4.5 at 135 KIAS. In PC configuration with gear up or down, the position error varied from -3 knots at 95 KIAS to +9 at 143 KIAS. The position error in power approach (PA) configuration was positive and had a value of +3 knots at 103 KIAS and varied to +8.5 knots at 123 KIAS. Paragraph 2.3.7.4.

The wing-boom (high-airspeed system) position error was nonlinear and was the same for all configurations. The position error varied from -7 knots at 110 KIAS to +.3 knots at 175 KIAS. The position error then decreased from +.3 knots at 175 KIAS to -1.5 knots at 230 KIAS and remained essentially the same to an airspeed of 293 KIAS. Paragraph 2.3.7.4.

1.5.4 TRANSITION STABILITY AND CONTROL

1.5.4.1 Hovering and Vertical Takeoff and Landing (VTOL) Operations

No adverse characteristics were observed due to the rapid application of collective control stick. Immediately after the main gear lift-off, the test aircraft exhibited moderate disturbances about all axes. The intensity of the disturbances decreased as wheel height increased and was completely eliminated at a wheel height of approximately 10 feet. Due to the severity of the disturbances, the ability to perform precise tasks in a zero- to 10-foot wheel height regime was questionable. This result dictated that all prolonged hover operations be conducted at wheel heights above 10 feet, where a single engine failure would result in aircraft damage and possible pilot injury.

This problem was complicated by two other unsatisfactory aircraft characteristics that became prominent during vertical takeoffs: engine reingestion and degradation of available lateral control power with increased collective stick position. The net effect of engine reingestion, fully discussed in Reference n, was to reduce total lift in fan-mode configuration. Reference n showed the intensity of engine reingestion to be a direct function of ambient wind conditions and suggested the 5-knot wind limitation for vertical takeoff adhered to during this evaluation. To the pilot, engine reingestion was noted by an apparent "hang-up" with little or no lift response to increased power application. To continue climb after encountering reingestion during operations in winds of 5 knots or less, a satisfactory technique was to change aircraft atti-

tude in pitch or yaw. This altered the air flow from the reingested pattern and thus permitted sufficient power to conduct a vertical climb. The second unsatisfactory characteristic was the inherent coupling of available lateral control power with collective position. At maximum engine power and a full-up collective, a severe degradation of control power from that available with a mid-collective position was noted.

Although not encountered during this evaluation due to the 5-knot wind limitation, it is easy to foresee the potential results of the combined effects of the three characteristics mentioned: with a lateral disturbance immediately at lift-off causing a low-wing attitude and engine reingestion causing the pilot to apply full lift stick to maintain climb, the combined reingestion and lateral control demand effects would reduce available lift to a lift-weight (L/W) ratio below 1 and the aircraft would settle to the ground in a wing-low attitude. Correction of each of the three unsatisfactory characteristics discussed is mandatory for follow-on XV-5 aircraft. A pilot opinion rating of 5.5 was assigned to the vertical takeoff characteristics. Paragraph 2.4.1.5.

1.5.4.2 Takeoff and Climb

The control requirements during a conventional takeoff and climb were small. Immediately after lift-off, there was a tendency toward pilot-induced lateral oscillations during climbout which was easily eliminated as pilot experience was obtained. Two takeoff flap settings, zero and 25 percent, were investigated at various horizontal stabilizer positions. Of the horizontal stabilizer positions investigated, -3.5 degrees and -2 degrees were optimum for takeoff with 25-percent and zero-percent flaps respectively. The zero-percent flap takeoff was the more desirable of the two flap configurations investigated. Directional control during takeoff ground run was effortless. Rudder effectiveness was noted at approximately 40 KIAS and aileron effectiveness was noted at 80 KIAS. A pilot opinion rating of 2.5 was assigned to the conventional takeoff characteristics observed during this evaluation. An associated problem encountered during conventional takeoff and climbout was the overheating of the right wing-fan cavity area. To reduce the cavity area below its overtemp condition (120 degrees Centigrade(C)), engine speed had to be retarded to approximately 96 percent RPM. This unsatisfactory performance limitation must be eliminated for follow-on XV-5 aircraft. Paragraph 2.4.2.5.1.

During the ground run portion of a fan-mode rolling takeoff, there were no undesirable stability and control characteristics. The vector angle was moved forward and the aircraft became airborne when sufficient vertical thrust was available. Aircraft lift-off

and rotation occurred at a vector angle of approximately 20 degrees and an airspeed of 50 KCAS. At this time roll and yaw rate oscillations were evident and were more pronounced at lower lift-off airspeeds. At vector angle positions greater than 20 degrees the fan control system was ineffective and the minimum climbout speed for this technique was approximately 45 KCAS. For takeoffs at airspeeds greater than 45 KCAS, the ground run acceleration technique was adequate and a pilot opinion rating of 4 was assigned. Paragraphs 2.4.2.4.2, 2.4.2.5.4.

Two undesirable characteristics were noted during 30-foot wheel height level accelerations from hover. During initial acceleration, achieved by increasing the angle of the wing-fan louvers, specific attention was required to insure that a "rule-of-thumb" relationship of 2 KIAS of airspeed for each degree of louver angle was maintained. If louver angle exceeded the 1:2 relationship with airspeed prior to 40 KIAS, a loss of lateral control power was observed. The lateral control power loss was attributed to the "washout" of fan control power as louver angle approached the maximum FM configuration setting of 45 degrees. The problem was confined to the lateral axis due to the previously discussed degradation of lateral control power in FM configuration with full-up lift stick. At airspeeds greater than 40 KIAS, sufficient aerodynamic lateral control power was available from ailerons to allow small deviations from the 1:2 relationship between louver angle and airspeed. The high degree of pilot attention required to maintain the louver angle airspeed schedule at airspeeds less than 40 KIAS was undesirable. There was insufficient nose-down trim authority during acceleration. A pilot opinion rating of 5 was assigned to the characteristics of the XV-5A observed during 30-foot wheel height level accelerations from hover. Paragraph 2.4.2.5.3.

The control movements were small during a stabilized fan-mode climb at speeds between 30 and 70 KIAS. High negative angles of attack did not introduce any significant adverse stability and control characteristics. A looseness of lateral and directional control was noted during 30 KIAS climbs as compared to climbs at airspeeds greater than 30 KIAS. A pilot opinion rating of 3 was assigned to the flying qualities of the XV-5A as observed during fan-mode climbs. Paragraph 2.4.2.5.5.

1.5.4.3 Landings

The jet-mode landing characteristics observed during conditions of no crosswind or turbulence were satisfactory. Under conditions of crosswinds or turbulence the narrow-track landing-gear geometry, low-power brakes and large aircraft side area all contributed to the poor crosswind landing characteristics. These poor

characteristics were observed in landing winds of less than a 5-knot crosswind component. The aircraft was firm on landing and exhibited no tendency to bounce or float during touchdown. Aerodynamic braking was possible by holding the nosewheel off the ground until approximately 85 KIAS, the minimum elevator effectiveness speed. "Wave off" characteristics from normal approaches were excellent with no loss of altitude or large trim changes involved. A pilot opinion rating of 3.5 was assigned to the conventional landing characteristics. Paragraph 2.4.2.5.2.

Precise positioning during vertical landings was limited by restricted downward vision and the disturbances discussed in Paragraph 1.5.4.2. Prior to a vertical landing the pilot was forced to select the proposed touchdown spot at a wheel height above 10 feet, then devote complete attention to lowering the aircraft through the region of increasing disturbance to the preselected landing spot. These characteristics were undesirable. Due to the narrow main landing gear and large aircraft side area, the possibility of a lateral "tip-over" due to a sideward translation at touchdown was always present during hover operations in wind. To reduce this risk, as well as engine reingestion effects, hover operations were restricted to winds of less than 5 knots. A pilot opinion rating of 5.5 was assigned to the fan-mode vertical landing characteristics. Paragraph 2.4.1.4.

1.5.4.4 Conversions

The conventional-to-fan-powered-flight conversion characteristics enhanced the flying qualities. Conversions were conducted in level flight at the following conditions: engine speed (97 percent - 100 percent), density altitude (4500 feet - 8500 feet), and airspeed (95 KIAS - 105 KIAS). All conversions were characterized by a mild pitch-over (from +13 degrees α to +5 degrees α) which required approximately 15 pounds of aft stick force to arrest without an altitude loss. A sensation of deceleration, similar to that following the extension of speed brakes in a conventional aircraft, was the most prominent "cockpit cue" of conversion. Additional cockpit cues were: horizontal stabilizer visual and aural signals' denoting the programmed movement of the stabilizer to the 10-degree leading-edge-up position, visual signal's denoting diverter valve in the lift-fan position and increased noise levels due to the three fans' coming up to speed. The increased noise level was of such magnitude that radio communications were impaired unless the pilot wore a snugly fitted flying helmet and oxygen face mask. Total time required for the conversion was approximately 3 seconds. Follow-on XV-5 aircraft should be provided with speed brakes to assist the pilot during the conventional to vertical (C-V) conversion as well as improve jet-mode deceleration characteristics. A pilot opinion

rating of 2.5 was assigned to the conventional-to-fan-powered-flight conversions observed during this evaluation. Paragraph 2.4.3.5.1.

Wings-level fan-powered-to-conventional-flight conversions were conducted both in level flight and during descents at airspeeds between 85 KIAS and 95 KIAS. All conversions were characterized by immediate acceleration and mild pitch-up that could be arrested with a 10-percent power reduction (100 percent to 90 percent). No specific control movement, other than throttle reduction, was required to maintain flight attitude following the conversion. The sensation of immediate acceleration was the most prominent "cockpit cue" of the conversion. Additional cues were: horizontal stabilizer visual and aural signals' denoting the programmed movement of the stabilizer to the -5 degree leading-edge-down position, the visual signal's denoting diverter valve in the conventionally powered position and the decreased cockpit noise level. Total time required for the conversion was approximately 1 second. These conversion characteristics, as observed during this evaluation, enhanced the flying qualities of the XV-5A, and a pilot opinion rating of 2 was assigned. Paragraph 2.4.3.5.1.

1.5.4.5 Transition Characteristics with the Stability Augmentation System Inoperative

The stability characteristics and control requirements during a SAS-off conversion were essentially the same as those for SAS-on condition. As the airspeed was decreased after conversion, a lateral-directional oscillation was encountered. The period of this oscillation was 2 seconds and the magnitude increased with decreasing airspeed. The overall stability continued to deteriorate with longitudinal and lateral stick inputs increasing in magnitude as airspeed was decreased to 35 KCAS. No significant directional control inputs were required during conversion and devectoring. Paragraph 2.4.4.4.1.

The stability during an acceleration from 35 KCAS was considerably better than during the deceleration. The lateral-directional oscillation was present but the magnitude was greatly reduced. A power cutback during the vectoring did not introduce any significant adverse stability and control characteristics. A 2-inch aft stick displacement was required to compensate for the reduction in pitching moment with power reductions. No rolling or yawing motions were associated with the power cutback. The stability characteristics during conversion to jet mode were similar to those in the SAS-on condition. Paragraph 2.4.4.4.1.

The lateral stability was weak during an acceleration from hover to 30 KCAS. Immediately after the vectoring was started there

was a lateral oscillation which reached a maximum at 8 KCAS. The stability improved as airspeed was further increased and the oscillation was damped. The longitudinal stability was positive with forward stick displacement required during the acceleration. Pedal requirements were similar to those with the SAS on. Paragraph 2.4.4.4.1.

A limited variable SAS investigation of hover characteristics above a 10-foot wheel height was conducted. The results of these tests indicated that attitude control about the pitch and yaw axes could be satisfactorily accomplished without stability augmentation. Attitude control about the roll axis required a minimum of 50 percent of test setting gains to provide adequate roll control during hover operations. The simulated control effects resulting from a single hydraulic failure were evaluated by reducing roll and yaw SAS gains to 50 percent of test settings and pitch SAS gains to zero. In this configuration the aircraft was controllable and, although not evaluated, it was believed that emergency vertical landing could be safely performed. The results of this phase of the evaluation indicated a mandatory requirement for a roll SAS during hover operations. Continued testing in this area should be conducted. Paragraph 2.4.1.5.

1.5.4.6 Fan-Mode Flight Limitation

The imposed 10-minute maximum duration for fan-mode flight was unsatisfactory. Paragraph 2.4.1.5.

1.5.4.7 Lift-Fan Operating Characteristics

Lift-Fan overspeed characteristics were observed during high-speed flight (65 KIAS - 95 KIAS) in FM configuration. These characteristics were undesirable and necessitated an automatic power cutback system which reduced engine speed to approximately 97 percent when lift-fan overspeed limits were exceeded. Although no objectionable flight characteristics were observed following automatic power cutback, normal pilot reaction was to avoid this occurrence. As a result the pilot was continually adjusting power with throttle manipulation to maintain a fixed fan RPM during an airspeed change. Paragraph 2.1.1.4.5.2.1.

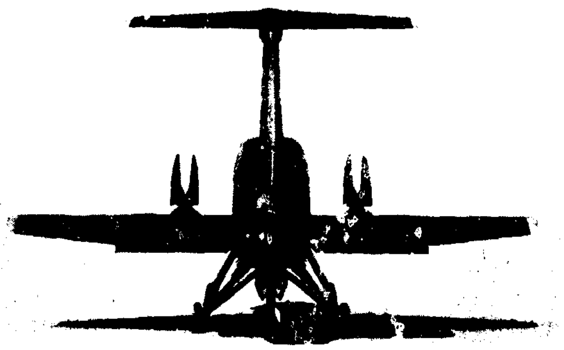


Photo 6- XV-5A
rear view, Fan-Mode

1.6 Conclusions

1.6.1 COCKPIT, FLIGHT CONTROL SYSTEMS AND GROUND HANDLING CHARACTERISTICS

Inflight cockpit temperature control was unsatisfactory. Various cockpit switches and instruments required repositioning. During hover operations downward vision was restricted. In addition, the canopy release provided no satisfactory "vent" position for use during ground operations and no positive canopy lock indication was available. Modifications to the fan-overspeed warning and fire warning systems were suggested in addition to a modified annunciator panel and master caution light. (Paragraphs 1.5.1.1, 1.5.1.2).

1.6.1.1 <u>Flight Control Systems</u>

Control breakout forces and force gradients were observed to be satisfactory about all axes in both jet-mode and fan-mode configurations. (Paragraph 1.5.1.3), PILOT OPINION RATING: 3.

1.6.1.2 <u>Ground Handling Characteristics</u>

The light-duty brakes and narrow main gear track were unsatisfactory. (Paragraph 1.5.1.4), PILOT OPINION RATING: 5.

1.6.2 FAN-MODE STABILITY AND CONTROL

1.6.2.1 <u>Static Trim Stability</u>

Static longitudinal trim stability was observed to be negative at airspeeds greater than 50 KCAS and positive for airspeeds below 50 KCAS. In addition, the longitudinal trim system provided insufficient nose-down trim authority between 32 KCAS and 72 KCAS. The lateral trim stability was nonlinear with airspeed due to the unsymmetrical phase-out of differential stagger with vector angle. (Paragraph 1.5.2.1), PILOT OPINION RATING: 3.5.

1.6.2.2 Static Longitudinal Stability

Negative stick-fixed and stick-free static longitudinal stability characteristics were observed at airspeeds greater than 50 KCAS. (Paragraph 1.5.2.2), PILOT OPINION RATING: 3.5.

1.6.2.3 Static Directional Stability and Effective Dihedral

During steady-heading sideslips, directional control inputs were characterized by light forces at airspeeds between 30 KCAS and 60 KCAS. (Paragraph 1.5.2.3), PILOT OPINION RATING: 3.

1.6.2.4 Static Stability During Sideward Flight

The directional control requirements during sideward flight were nonlinear with control reversals occurring during lateral translations both to the right and left. The lateral trim stability was positive and slightly nonlinear over the speed range investigated. An increasing nose-up longitudinal pitching moment was encountered as the speed was increased in either direction. (Paragraph 1.5.2.4), PILOT OPINION RATING: 3.5.

1.6.2.5 Static Stability During Rearward Flight

The longitudinal trim stability was positive during low-speed (18 KCAS maximum) forward and rearward flight. (Paragraph 1.5.2.5), PILOT OPINION RATING: 2.5.

1.6.2.6 Dynamic Longitudinal Stability (SAS On)

The longitudinal disturbances were well-damped over the entire fan-mode airspeed envelope. Typically there was a small characteristic overshoot with no residual oscillations. (Paragraph 1.5.2.6), PILOT OPINION RATING: 2.

1.6.2.7 Dynamic Lateral-Directional Stability (SAS On)

A lateral disturbance resulted in a highly damped lateral oscillation for all airspeeds less than 75 KCAS. No lateral-directional coupling was observed during hovering flight. At airspeeds greater than 30 KCAS, directional disturbances were observed to result in an increasing amount of roll coupling. (Paragraph 1.5.2.7), PILOT OPINION RATING: 3.5.

1.6.2.8 Dynamic Directional Stability (SAS On)

No objectionable flight characteristics were observed during this portion of the evaluation. (Paragraph 1.5.2.8), PILOT OPINION RATING: 3.

1.6.2.9 Controllability (SAS On)

The controllability characteristics were adequate for the research mission. (Paragraph 1.5.2.9), PILOT OPINION RATING: 3.

1.6.3 JET-MODE STABILITY AND CONTROL

1.6.3.1 Longitudinal Trim Changes

The longitudinal trim changes with variations of flap settings and fan configuration exceeded 10 pounds stick force in most cases. (Paragraph 1.5.3.2, PILOT OPINION RATING: 3.

1.6.3.2 Longitudinal Trim Stability

During this evaluation, two trim rates were evaluated in jet-mode flight. The .2-deg/second horizontal stabilizer trim rate was too slow at airspeeds less than 150 KIAS. The previous .4-deg/second trim rate observed during the early portion of the evaluation was too fast at airspeeds in excess of 250 KIAS. (Paragraph 1.5.3.2), PILOT OPINION RATING: 4.

1.6.3.3 Static Longitudinal Stability

The stick-fixed and stick-free static longitudinal stability were positive for the flight conditions tested. Shallow positive stick force gradients and large trim-bands about the trim airspeeds described typical static longitudinal stability characteristics in PC and CR configurations. (Paragraph 1.5.3.3), PILOT OPINION RATING: 3.

1.6.3.4 Static Directional Stability and Effective Dihedral

Pedal-fixed and pedal-free stability were positive for all conditions tested. The stick-fixed dihedral effect was positive for all conditions tested. No undesirable flight characteristics were observed during this portion of the lateral-directional investigation. In PC configuration at 140 KIAS, the aircraft tended to oscillate laterally after a wind gust disturbance. This oscillation damped with airspeed reduction. (Paragraph 1.5.3.4), PILOT OPINION RATING: 3.

1.6.3.5 Stall Characteristics

A limited contractor-conducted investigation of power-on stalls was conducted. During this investigation an undesirable post stall gyration was encountered. Future investigations in this area

should be conducted and should include the determination of the effectiveness of power reduction on a power-on stall recovery technique. (Paragraph 1.5.3.5).

1.6.3.6 Asymmetric Power

Adequate lateral control and directional control were available at airspeeds greater than 120 KIAS with one engine at idle power setting. No objectionable flying qualities were encountered during these limited tests. (Paragraph 1.5.3.6), PILOT OPINION RATING: 2.

1.6.3.7 Dynamic Stability

No objectionable flight characteristics were observed during this portion of the evaluation. (Paragraph 1.5.3.7), PILOT OPINION RATING: 2.5.

1.6.4 TRANSITION STABILITY AND CONTROL

1.6.4.1 Hovering and VTOL Operations

Three unsatisfactory characteristics were noted during VTOL operations in close proximity to the ground (from zero wheel height to 10-foot wheel height). Aircraft disturbances, engine reingestion and degradation of lateral control power characteristics were all observed with the specified wheel height region. (Paragraph 1.5.4.1), PILOT OPINION RATING: 5.5.

1.6.4.2 Takeoff and Climb

No objectionable characteristics were observed during conventional takeoffs. Immediately after lift-off there was a tendency toward pilot-induced lateral oscillations during climbout which was easily eliminated as pilot experience was obtained. (Paragraph 1.5.4.2), PILOT OPINION RATING: 2.5.

An associated problem encountered during conventional takeoff and climbout was the overheating of the right wing-fan-cavity area which resulted in a performance limitation. (Paragraph 1.5.4.2).

The minimum practical climbout speed for the fan-mode rolling takeoff technique was 45 KCAS. (Paragraph 1.5.4.2), PILOT OPINION RATING: 4.

Two undesirable characteristics were noted during 30-foot wheel height level accelerations from hover. The requirement to maintain a precise louver angle-airspeed relationship at airspeeds

less than 40 KIAS was tedious. In addition there was insufficient aircraft nose-down trim authority. (Paragraph 1.5.4.2), PILOT OPINION RATING: 5.

Fan-mode climbs were characterized by a looseness of lateral-directional control noted during 30-KIAS climbs as compared with climbs at airspeeds greater than 30 KIAS. (Paragraph 1.5.4.2), PILOT OPINION RATING: 3.

1.6.4.3 Landings

The jet-mode landing characteristics without crosswind or turbulence were satisfactory. The narrow-track landing-gear geometry, low-power brakes and large aircraft side area all contributed to poor crosswind landing characteristics in landing winds of less than a 5-knot crosswind component. (Paragraph 1.5.4.3), PILOT OPINION RATING: 3.5.

Precise vertical landings were limited by the aircraft disturbances observed in increasing severity from 10-foot wheel height to zero wheel height. Crosswind characteristics were poor, as discussed in the preceding paragraph. Restricted downward vision and landing gear location prevented the pilot from obtaining precise wheel height information during vertical landings. (Paragraph 1.5.4.3), PILOT OPINION RATING: 5.5.

1.6.4.4 Conversions

The conventional-to-fan-powered-flight conversion characteristics enhanced the flying qualities. Conversions were characterized by a mild pitch-over which required approximately 15 pounds of aft stick to arrest without an altitude loss. The addition of speed brakes would assist the pilot during the C-V conversion as well as improve jet-mode deceleration characteristics. (Paragraph 1.5.4.4), PILOT OPINION RATING: 2.5.

The fan-powered-to-conventional-flight conversions were characterized by immediate acceleration and mild pitch-up that could be arrested with a 10-percent power reduction. (Paragraph 1.5.4.4), PILOT OPINION RATING: 2.

1.6.4.5 Transition Characteristics with the Stability Augmentation System Inoperative

The stability characteristics and control requirements during a SAS-off conversion were essentially the same as those for SAS-on condition. As the airspeed was decreased after conversion the overall stability deteriorated. The results of a limited

variable SAS investigation during hover indicated that a mandatory requirement for a roll SAS existed. (Paragraph 1.5.4.5).

1.6.4.6 Flight Limitations

The imposed 10-minute flight duration limitation in FM configuration was unsatisfactory. (Paragraph 1.5.4.6).

1.6.4.7 Lift-Fan Operating Characteristics

Lift-fan overspeed characteristics were present during high-speed fan-mode flight. These characteristics were undesirable and necessitated an automatic power-cutback system. (Paragraph 1.5.4.7).

1.7 Recommendations

1.7.1 MANDATORY

It is recommended that the following items be corrected on a mandatory basis for follow-on XV-5 aircraft:

a. Cockpit temperature control system (Paragraph 1.6.1).

b. Light-duty brakes and narrow main gear track (Paragraph 1.6.1.2).

c. Vertical takeoff and landing characteristics in close proximity to the ground (Paragraph 1.6.4.1).

d. Lift-stick-lateral-control-stick coupling characteristic (Paragraph 1.6.4.1).

e. Engine reingestion characteristic (Paragraph 1.6.4.1).

f. Wing lift-fan-cavity over-heating characteristic (Paragraph 1.6.4.2).

1.7.2 DESIRABLE

It is recommended that the following items be corrected on a priority basis for follow-on XV-5 aircraft:

a. Existing cockpit switch and instrument locations (Paragraph 1.6.1).

b. Canopy release mechanism (Paragraph 1.6.1).

c. Unsymmetrical phase-out of differential stagger with vector angle (Paragraph 1.6.2.1).

d. Negative static longitudinal stability characteristics in fan-mode configuration (Paragraph 1.6.2.2).

e. Directional stability characteristics during sideward flight (Paragraph 1.6.2.4).

f. Longitudinal trimmability characteristics in jet-fan-powered configurations (Paragraph 1.6.3.2, 1.6.2.1).

g. Lateral wind-gust sensitivity in PC configuration (Paragraph 1.6.3.4).

h. Acceleration characteristics in fan-mode configuration (Paragraph 1.6.4.2).

i. Jet-mode and vertical landing characteristics in cross-wind (Paragraph 1.6.4.3).

j. Limited downward vision from the cockpit (Paragraph 1.6.4.3).

k. Lack of speed brakes (Paragraph 1.6.4.4).

l. Lift-fan overspeed characteristics (Paragraph 1.6.4.7).

■1.7.3 GENERAL

It is recommended that the following items be considered during any further development of this configuration and/or concept:

a. Conduct additional testing to establish the flight envelope limiting factors (Paragraph 2.0).

b. Conduct additional testing to determine the correlation between flight and ground test control system data (Paragraph 1.5.1.3).

c. Conduct additional testing to evaluate lower stick forces during low-speed maneuvering flight (Paragraph 1.5.1.3).

d. Conduct additional testing to evaluate increased directional stability at airspeeds between 30 KCAS and 60 KCAS (Paragraph 1.5.2.3).

e. Conduct additional testing to evaluate increased directional controllability during hover (Paragraph 1.5.2.9.3).

f. Conduct additional testing to evaluate the suitability of static longitudinal stability characteristics in turbulent air (Paragraph 1.5.3.3).

g. Reduce the full-flap-extension maximum airspeed limit to 140 KIAS (Paragraph 1.5.3.4).

h. Conduct additional testing to define the stall characteristics and establish proper stall recovery techniques (Paragraph 1.5.3.5).

i. Conduct additional testing to obtain SAS optimization (Paragraph 1.5.4.5).

SECTION 2 - DETAILS OF TEST

2.0 INTRODUCTION

This engineering flight research evaluation of the XV-5A aircraft was conducted to fulfill the objectives stated in Paragraph 1.1. This report presents the stability and control portion of the evaluation. The program was conducted by USAAVNTA at Edwards Air Force Base, California. Testing consisted of 24.2 productive flight hours and was accomplished from 28 January 1965 to 30 June 1965. The results of the performance evaluation will be presented in Part II, which will be published at a later date.

The test program was conducted within the flight envelope established by the contractor. During the program, flights were made by the contractor pilots to expand the flight envelope for further evaluation of the aircraft capability. All other flights were conducted under the direction of the U. S. Army Test Team.

The test group consisted of a USAAVNMLABS Program Manager, a USAAVNTA Test Director, and combined USAAVNMLABS/USAAVNTA engineers and test pilots. The contractor provided logistics, maintenance, instrumentation, and engineering support. A detailed description of responsibilities is contained in Appendix VIII.

Tests were conducted in non-turbulent atmospheric conditions so that the data would not be influenced by uncontrolled disturbances. The design gross weight for the XV-5A was 9200 pounds. The average gross weight used during this test program was 10,000 pounds.

The following sequence was followed to provide the safest and most logical testing. First, the static stability tests were conducted to determine the areas of static instability; after the majority of these tests had been accomplished, the dynamic stability and controllability tests were accomplished.

The test instrumentation used during the program was supplied, calibrated, installed, and maintained by the contractor. The problems encountered with the instrumentation during the program are described in Appendix V.

Unless otherwise specified in this report all airspeeds are calibrated values (CAS) and altitudes are pressure altitudes (H_p).

An appropriate pilot rating system was developed and used throughout the report in order to correlate the pilot opinion of

specific flight characteristics with the quantitative test data. The pilot opinion ratings apply to the aircraft as it was operated for a research mission in a controlled environment. The ratings do not necessarily reflect the pilot opinions that would result from operation in a field environment.

As is the case with most experimental aircraft the XV-5A flight envelope was progressively expanded as flight experience was obtained. Appendix IV shows the current flight and operation limits. Additional testing should be conducted to establish the flight envelope limiting factors.

2.1 COCKPIT AND FLIGHT CONTROL SYSTEMS

2.1.1 COCKPIT

2.1.1.1 Objective

The objective of the cockpit evaluation was to determine pilot suitability, pilot comfort, and functional relationships of the unique instrument display and cockpit controls.

2.1.1.2 Method

The evaluation was conducted by use of graphical cockpit instrument displays, a full-scale simulator, and by observation during static and inflight aircraft conditions. First impressions and opinions resulting from experience were integrated to obtain the overall evaluation. Parameter importance and pilot requirements were evaluated to arrive at recommended instrument display changes. Changes during the flight program were primarily limited to flight safety items.

2.1.1.3 Results

Results are presented in the following paragraphs.

2.1.1.4 Analysis

2.1.1.4.1 Field of Vision

Visibility forward, upward and sideward was good. Visibility downward and aft was restricted. While hovering at low wheel heights, vertical orientation and landing visibility were satisfactory. At high hovering heights or vertical approaches above 500 feet, the lack of downward visibility resulted in poor ground reference and made it difficult to accomplish a precise vertical landing. The overall visibility was satisfactory for

this evaluation; however, the restricted downward visibility could be a significant factor in an operational aircraft. Recommendation 1.7.2j

2.1.1.4.2 Comfort

The cockpit area was large and provided ample space for a 6-foot, 190-pound pilot. Ventilation provided by ambient air drawn in through small vents along the canopy periphery was unsatisfactory. These vents were inadequate to provide satisfactory cooling during high-temperature ambient conditions. The cockpit was situated in a hot airframe environment, and the introduction of high-temperature atmospheric or recirculating air added to the problem. Cockpit ambient temperature was not recorded during the evaluation; however, in many cases the high temperatures significantly affected pilot comfort. Over an extended period, this also detracted from pilot performance. The vents could not be closed by the pilot, and temperature could not be controlled during low-temperature ambient conditions. Recommendation 1.7.1a

Acoustical cockpit sealing was also unsatisfactory. During flight in fan-mode (FM) configuration and high-speed (350 knots indicated airspeed (KIAS)) flight in jet-mode (JM) configuration, cockpit noise level was excessive. In FM configuration, radio communication was impaired by the noise.

2.1.1.4.3 Controls

All switches and controls were within easy pilot reach except the oxygen diluter valve and quantity gage, which were to the right rear of the pilot. Both the diluter valve and the gage should be repositioned for easy pilot access. Recommendation 1.7.2a

The canopy mechanism provided no satisfactory vent position for use during ground operations. In addition, no canopy lock indication was provided; this resulted in doubt as to the actual position of the canopy latch. The following modifications would improve the canopy control system: Recommendation 1.7.2b

a. Provide positively identified lock and vent positions for the control handle.

b. Provide a "down-and-locked" light or pointer which is independent of the handle position.

The throttle quadrant should be modified to preclude inadvertent throttle disengagement and/or engine shutoff. Both situations were experionced during this evaluation. Recommendation 1.7.2a

2.1.1.4.4 Instruments

The rate of climb, low airspeed indicator and high airspeed indicator were poorly positioned for pilot scanning. During fan-powered flight, the primary instruments were: angle of attack, rate of climb and low airspeed indicator. An improvement in the instrument presentation, therefore, would be to locate these instruments from the left to right along the top of the instrument panel: angle of attack, rate of climb, low airspeed indicator and high airspeed indicator.

A further instrumentation recommendation is to offset the right side of the instrument panel so that pilot vision is normal to the engine and fan instruments. The changes to instrument locations shown in Table 1 and Figures 1 and 2 are recommended:

It is considered that accomplishment of these changes would provide the pilot with excellent density of engine and fan instrumentation to accomplish data acquisition. For operational aircraft, considerable "clean-up" and standardization of instrument layout are required. Recommendation 1.7.2a

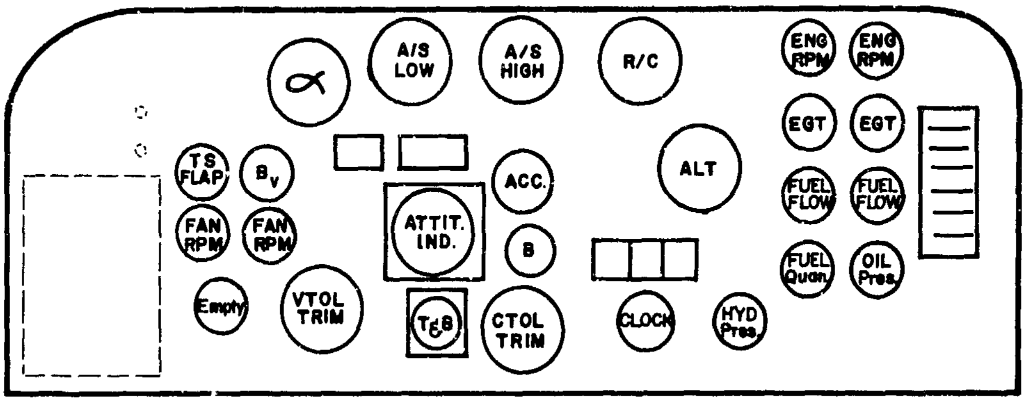


FIGURE 1 - EXISTING INSTRUMENT PRESENATION

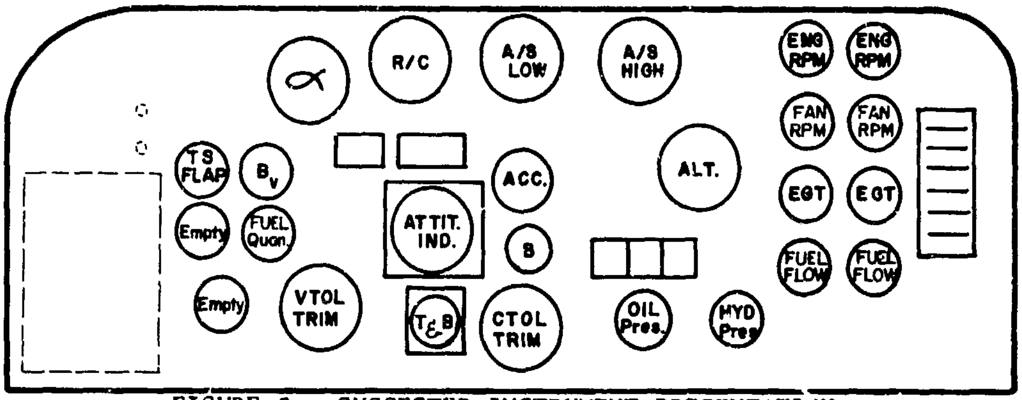


FIGURE 2 - SUGGESTED INSTRUMENT PRESENTATION

2.1.1.4.5 Emergency Operations and Warning Systems

2.1.1.4.5.1 Emergency Operations

The test aircraft was equipped with sufficient warning devices and redundant systems to enable the pilot to identify and correct emergency situations. Conversions could be aborted at any time and the aircraft immediately returned to the configuration that existed prior to the conversion initiation. Cockpit warning devices consisted of a 17-item annunciator panel with master caution light and the following warning devices with associated conditions:

Warning Device	Condition
Visual	Engine Fire and Compartment Overheat
Visual and Aural	Unsafe Landing Gear
Visual and Aural	Horizontal Stabilizer Movement
Visual	Manual Wing-Fan Louver Movement

Visual	Structural Overheat
Visual	Low Fuel Pressure
Visual	Low Fuel Quantity
Visual	Malfunctioning Electrical System

Dual hydraulic, stability augmentation and electrical systems were installed. A battery designed to supply full capability electrical power for approximately 5 minutes was provided for use if both the primary and secondary electrical systems failed. Two fire extinguisher systems were available for inflight use for either engine compartment. A rocket-powered ejection seat was installed. These emergency provisions were adequate for the safe conduct of the flight evaluation.

2.1.1.4.5.2 Warning Systems

2.1.1.4.5.2.1 Fan-Overspeed Protection System

When the fan-overspeed protection system sensed 101-percent wing-fan RPM or 106-percent pitch-fan RPM, the master caution light and appropriate annunciator lights were activated. To extinguish the annunciator panel caution light it was necessary to reduce wing-fan RPM to approximately 95 percent and pitch-fan RPM to approximately 100 percent. The power reduction resulted in a loss of altitude which was a function of power required at the flight condition. If wing-fan RPM increased to 103-percent and/or pitch-fan RPM increased to 110-percent structural limit RPM in both cases, an automatic power cutback occurred which reduced engine RPM to approximately 97 percent, thus causing a reduction of wing-fan and pitch-fan RPM. The automatic power cutback system, which was operational only at louver angles exceeding 30 degrees, did not result in objectionable flight characteristics. To reset power after an automatic cutback, activation of one of two power reset switches was required prior to increasing engine speed. This reset required approximately 1 second. Due to the unsatisfactory wing-fan overspeed characteristics that were observed during high-speed flight (65 KIAS to 95 KIAS), testing in this regime was usually conducted with the fan-overspeed caution light activated. This operation nullified the primary purpose of the caution light. The fan-overspeed protection system should be modified so that the caution light will be activated only when automatic power cutback occurs. After normal power reset procedures had been completed, the caution light was automatically deactivated, extinguishing the master caution light. Recommendation 1.7.21

2.1.1.4.5.2.2 Fire-Warning System

The fire warning/overheat warning lights were not supplemented by attention-getting audio signals and might not be observed when attention was directed outside the cockpit, i.e., during formation flying, transitioning to hover, hovering, landing, and takeoff. The illumination of these lights should cause peripheral attention-getting lights and audio warning to operate. The "arm/safe" and "normal/alternate" switches were separate and had to be operated in sequence to activate the fire extinguishing system. This was time consuming and imposed an excessive burden on the pilot during an emergency situation. When the decision to operate a fire bottle is made, no further decisions or reasoning should be required, and a single pilot action should activate the bottles. In this case, comments regarding activation of the fire bottles would not apply.

2.1.1.4.5.2.3 Annunciator Panel and Master Caution Light

The annunciator panel which was placed in the center of the instrument panel, not angled toward the pilot was subject to sun glare and reflections. It was occasionally necessary to lean to the right to confirm lettering. The illumination of the segments was insufficient to overcome bright sunlight. No distinction was made between urgent warnings and precautionary warning; for this reason, the degree of urgency was not immediately apparent to the pilot.

A master caution light was provided to draw the pilot's attention to a warning displayed on the annunciator panel. The following discrepancies detracted from the effectiveness of the master caution light:

a. It was partially obscured by the drag chute operating handle.

b. It was a steady, rather than a flashing, light regardless of the nature of the warning on the annunciator panel.

c. It was effective only when the pilot was looking forward.

d. It was similar in appearance to the fire-warning lights and, therefore, susceptible to confusion in an emergency.

e. No audio warning was associated with the illumination of this light.

2.1.2 FLIGHT CONTROL SYSTEMS

2.1.2.1 Objective

The objective of these tests was to obtain control force gradients and breakout forces in both the JM and FM configurations. JM and FM control position variations with stick position were also obtained during these tests.

2.1.2.2 Method

The aircraft was placed in the hangar with the required external ground-support equipment connected. The control was then displaced from the trim condition at a rate of .1 to .2 inches/second. A continuous record of all parameters was taken during the test.

2.1.2.3 Results

The test results are presented in Figures 1 through 31, Section 3, Appendix I.

2.1.2.4 Quantitative Engineering Analysis

2.1.2.4.1 General

The test aircraft has two basic primary control systems: the fan control system and the conventional control system. Both of these control systems are operated by the conventional cockpit controls. The fan controls are automatically phased in and out of the control system by means of a mechanical mixer as vector angle is varied. The control moments from the fan control system are achieved by vectoring and modulating the vectored thrust from the nose and wing fans. The conventional control system is operable during all flight conditions, and the control moments are achieved by means of aerodynamic control surfaces.

The aircraft is equipped with a collective control (lift stick) in addition to the conventional controls. This control is mechanically coupled to the wing-fan exit louvers. Lowering the collective increases the differential beta stagger ($\Delta\beta_s$) (see paragraph 2.4, Appendix I) and decreases fan lift by spoiling the thrust. This control can be used to control aircraft altitude and rate of climb or descent.

Prior to any flight testing, the rigging of the aircraft was checked for compliance with contractor specifications. The initial contractor rigging procedures were in many cases inadequate

to insure repeatability. These rigging procedures were modified and rewritten as the program progressed to increase the repeatability of the rigging.

2.1.2.4.2 Longitudinal Control and Force Systems

2.1.2.4.2.1 Longitudinal Control System

Longitudinal movement of the stick controlled the pitch-fan modulator doors and the conventional elevator during FM flight. The elevator motion with respect to longitudinal stick displacement remained the same regardless of the flight mode. The position of the pitch-fan door with respect to longitudinal control position was programmed with vector angle position. The reduction of longitudinal stick authority for the pitch-fan door with increasing vector angle is shown in Figure 23, Appendix I. Approximately ±.13 inches of control free play was encountered at the trim position in fan mode.

The position of the pitch-fan door varied as a function of collective control position. This is shown in Figure 22 , Appendix I.

2.1.2.4.2.2 Longitudinal Force System

The longitudinal control forces in the jet mode were trimmed by adjustment of the horizontal stabilizer which was positioned by means of an electrically operated screw jack. During FM flight at vector angles less than 30 degrees, the longitudinal control forces were trimmed by adjustment of a trim force system. At vector angles greater than 30 degrees, the longitudinal forces were trimmed by the use of the horizontal stabilizer. The horizontal stabilizer, at vector angles of less than 30 degrees, was normally fixed in the full trailing-edge-down position of 20 degrees. The horizontal stabilizer was trimmable at all vector angles by using the emergency trim system.

The longitudinal breakout forces were approximately 1.0 pound. The force required to move the control full aft was 6.0 pounds pull and 3.0 pounds push for full forward. These characteristics were similar for jet mode, pre-conversion, and fan mode at maximum beta vector angle (β_v) (See Appendix I).

The longitudinal breakout force in the fan mode varied as the β_v setting was changed. This variation was linear with 3.6 pounds at -2.7 degrees and .6 pounds at 34.7 degrees. These breakout forces were the same for both a forward and an aft stick displacement of .25 inches from trim. The unusually large break-

out forces were probably due to friction in the mechanical mixer. This friction reduced from 3.6 pounds to .6 pounds as the mixer box was phased out as a function of vector angle. The frictional force was additive to the spring package gradient.

The longitudinal force gradient in the fan mode varied with beta vector angle setting. The gradient 1 inch aft of trim changed from 1.0 pound/inch for a vector angle of -2.7 degrees to zero at a vector setting of +34.6 degrees. The slope of the stick-force-versus-displacement curve remained positive but decreased with aft displacement and increased with forward displacement. No significant discontinuities were present during either forward or aft stick displacement.

The longitudinal stick position for zero forces varied as beta vector angle was changed. An increase in beta vector angle caused the position for zero stick force to move forward. The position of the longitudinal stick varied from 3.2 inches to 5.9 inches forward of neutral for a beta vector angle setting of -2.7 and 34.6 degrees. This change in stick position with beta vector angle resulted in a large variation in stick force gradient for forward displacement.

2.1.2.4.3 Lateral Control and Force Systems

2.1.2.4.3.1 Lateral Control System

Lateral motion of the stick controlled two functions in a manner similar to that of the longitudinal stick. The lateral stick determined the amount of differential louver stagger input during FM flight. The differential stagger as a function of lateral stick input varied with vector angle. This differential stagger washout with increased vector angle was accomplished in the mechanical mixer box. The variation in differential stagger as a function of vector angle is shown in Figure 25, Appendix I. The lateral control system in fan mode had ±.15 inches of free play about a trimmed stick condition.

The ailerons functioned during all modes of flight. Symmetrical aileron deflection was programmed automatically with flap deflection. The maximum aileron droop was 15 degrees and occurred at a flap deflection of 45 degrees. This 1- to -3 aileron droop ratio was maintained throughout the flap deflection range.

2.1.2.4.3.2 Lateral Force System

The lateral control forces in the jet mode were

trimmed by use of an electrically operated screw jack attached to the left aileron tab. During FM flight, at vector angles less than 30 degrees the lateral control forces were trimmed by adjustment of a trim force system. The authority of the trim force system was decreased with vector angle and became zero at 30 degrees. At vector angles above 30 degrees the lateral forces were trimmed by means of the conventional aileron tab.

The lateral breakout force was approximately 1.0 pound both to the left and to the right for a control movement of .25 inches from trim. The force required to move the control full deflection was 4.0 pounds right (3.4 inches) and 3.0 pounds left (3.0 inches). These characteristics were similar for jet mode, pre-conversion and fan mode for maximum beta vector angle.

The lateral breakout force in fan mode was a function of vector-angle position. The breakout force varied from 1.9 pounds to .75 pounds for both a right and left stick displacement at a beta vector angle of -2.7 degrees and 34.6 degrees. These breakout forces were measured at .25 inches from trim.

The lateral force gradient in fan mode varied slightly with beta vector angle setting. The gradient was .7 pounds/inch at a vector angle of -2.7 degrees and .35 pounds/inch at a vector angle of 34.6 degrees. This gradient was encountered at 1-inch right and left of trim. The slope of the stick force to control displacement gradient was positive for left and right stick movement from trim.

2.1.2.4.4 Directional Control and Force Systems

2.1.2.4.4.1 <u>Directional Control System</u>

In fan mode, directional control deflections caused a combined wing-fan-louver and conventional-rudder motion. When a pedal input was applied, a corresponding change in differential vector angle (yawing moment) and an associated differential stagger input (rolling moment) in the direction of a favorable roll control input occurred. This programming of differential stagger had two functions: a. Correction of any adverse roll with yaw control inputs; and b. Providing dihedral effect during FM flight. The amount of differential stagger input as a function of vector angle and pedal input are graphically presented in Figure 29 , Appendix I. The differential vector input per inch of pedal deflection varied with vector angle and was washed out in the mechanical mixer box as the vector angle was increased. The directional control system had ±.25 inches of free play about a

trimmed stick condition. The differential vector variation as a function of vector angle is presented in Figure 28, Appendix I.

A conventional rudder was used for directional control during JM flight. This flap-type aerodynamic control was operative during all modes of flight. The rudder deflection as a function of pedal displacement was linear.

2.1.2.4.4.2 Directional Force System

During JM flight, the directional control forces were trimmed by use of the rudder tab. The directional control forces were trimmed by adjustment of a spring package at vector angles of 30 degrees or less. The authority of the trim package was washed out as vector angle was increased. At vector angles greater than 30 degrees the directional forces were trimmed by use of the conventional rudder trim tab.

The directional breakout force at the trim condition was approximately 1.0 pound for a control movement of .25 inches to the right or left. Six pounds of force were required to move the controls full left and right. This force was the same for jet mode, pre-conversion and fan mode for maximum beta-vector angle.

The directional breakout force in fan mode varied with beta vector angle position. The maximum breakout force was 5 pounds at -2.7 degrees beta vector angle and the minimum was 1.0 pound at 34.5 degrees vector angle. These breakout forces were measured at .25 inches from trim both to the left and to the right.

The directional force gradient in fan mode varied as the beta vector angle setting was changed. The gradient 1 inch from trim changed from 1.7 pounds/inch at a vector position of -2.7 degrees to zero pounds/inch at a vector position of 26.7 degrees. The directional force gradient was positive for right and left pedal displacement with increasing force required for pedal movement. No significant discontinuities were present.

2.1.2.4.5 Collective Control and Force Systems

2.1.2.4.5.1 Collective Control System

The collective stick control was used in FM flight only. The collective stick motion controlled the collective stagger of the wing fans as well as a small amount of the pitch-fan door motion. The authority of the collective control

diminished rapidly at high vector angles. The collective stick was used to control altitude by increasing or decreasing the thrust from the fans. The control of the thrust was accomplished by varying the collective stagger. This in turn spoiled thrust.

2.1.2.4.5.2 Collective Force System

The collective control system had no frictional adjustment. The gradient was preset before flight and was constant regardless of vector position.

2.1.2.4.6 Vector Command Select Switch

The vector command switch was used to control the position of the wing-fan louvers. The control of the louvers was accomplished by use of a roller switch located at the top of the control stick. The activation of the louvers changed the thrust vector angle. The beta vector angle was the average louver angle of the fan system. As the vector angle was increased, the wing-fan thrust changed from a vertical lifting force to a combination of horizontal and vertical thrust.

2.1.2.5 Pilot Qualitative Comments (Pilot Opinion Rating: 3)

2.1.2.5.1 Longitudinal Control System

The longitudinal breakout force and force gradients were satisfactory during hovering flight. The high forces measured during the static tests were not apparent to the pilot. For translational maneuvering at low speeds, the control force gradients were too high. In general, the reduced spring and friction force due to increased beta vector were replaced by increased aerodynamic feedback forces and resulted in a reasonably consistent control force "feel" over the FM speed range. Recommendation 1.7.3c

2.1.2.5.2 Lateral Control System

During FM flight, the lateral control system exhibited adequate force characteristics. The lateral control forces were lower than the longitudinal forces producing good control harmony. The lateral control forces, however, were still higher than optimum for lateral translational maneuvers at low speed and during sideward flight.

For the conventional and pre-conversion flight regimes no artificial lateral "feel" system nor lateral stick centering was provided. This, combined with high roll control

power, produced very sensitive lateral control characteristics. This sensitivity was particularly marked during flight with the flaps down. A lateral stick centering system should reduce the tendency to over-control in these flight regimes.

2.1.2.5.3 Directional Control System

During hovering flight, when no aerodynamic feedback was present, the shallow force gradient and low breakout force produced a directional control system with practically no "feel" characteristics. As forward speed was increased, aerodynamic feedback increased the force gradient to that approaching the conventional regime gradient. The system provided a smooth change in characteristics through transition.

Conventional and pre-conversion mode control system characteristics in flight exhibited no unusual characteristics and were similar to those encountered in most conventional fixed-wing aircraft.

2.1.2.6 Ground Handling Characteristics

The light-duty brakes and narrow main gear track (8.39 feet, wheel to wheel) caused prolonged taxiing to be precarious. The use of thrust spoilers to reduce residual thrust as an additional braking technique did not satisfactorily alleviate this problem. These characteristics were assigned a pilot opinion rating of 5. Recommendation 1.7.1b

2.2 FAN-MODE STABILITY AND CONTROL

2.2.1 FAN-MODE STATIC TRIM STABILITY

2.2.1.1 Objective

The objective of these tests was to investigate the static trim stability and flying qualities as the trim airspeed was varied. Additional tests were conducted to evaluate the louver vector and horizontal stabilizer trim effectiveness as a function of airspeed.

2.2.1.2 Method

The static trim stability was investigated by trimming the aircraft at different combinations of airspeed and angle of attack. While the aircraft was stabilized, all control forces, control positions, and aircraft attitudes were recorded.

The louver vector trim effectiveness was evaluated by

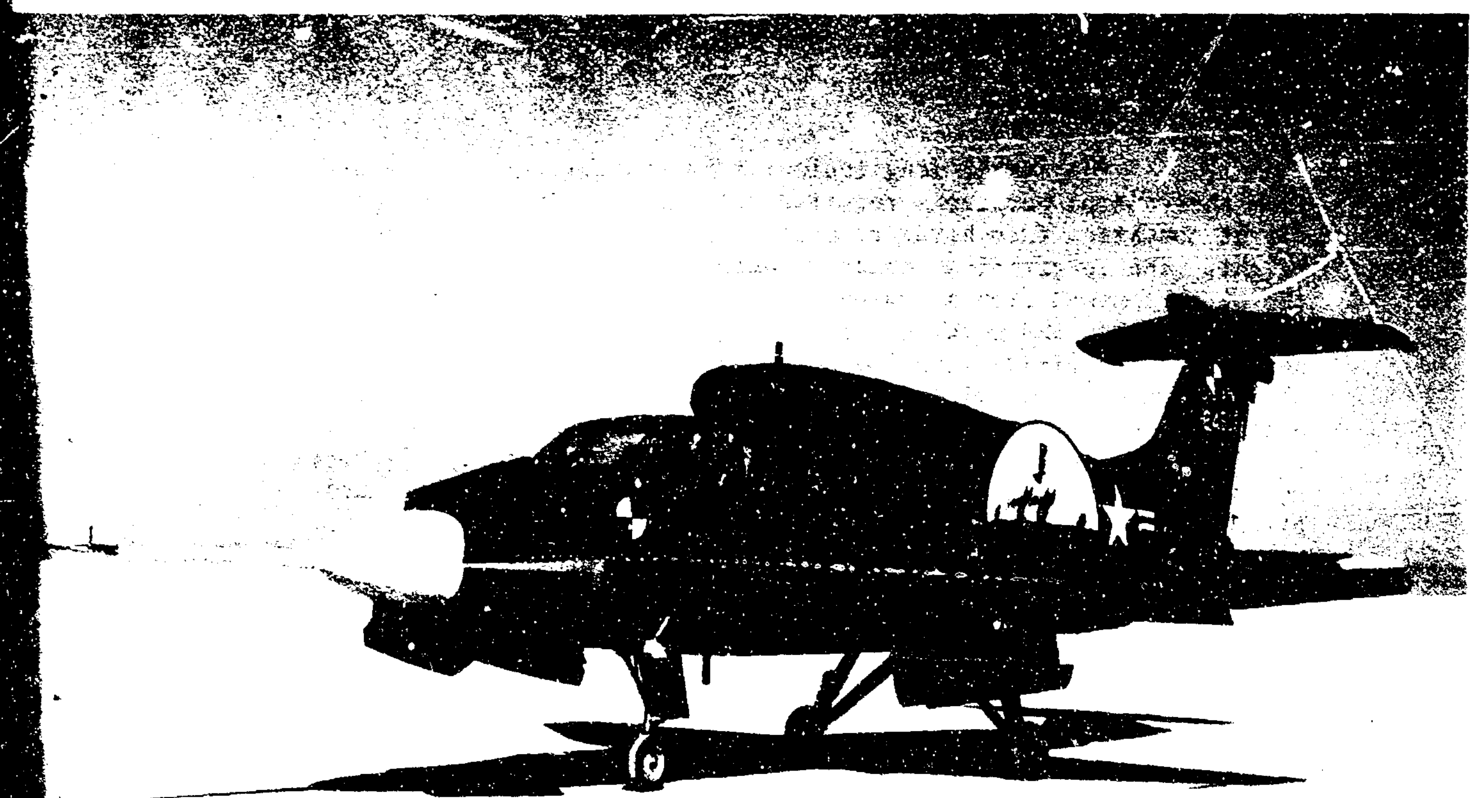


Photo 7- XV-5A In Fan-Mode

first trimming the aircraft at the desired level flight conditions. The louver vector angle was then varied while a constant angle of attack was maintained. The resulting airspeed, control forces, control positions and attitudes were recorded at each stabilized point.

The horizontal stabilizer trim effectiveness was investigated by first trimming the aircraft at the specified level flight trim conditions. The horizontal stabilizer position was then varied while the trim airspeed and angle of attack were maintained. Control forces, control positions and aircraft attitudes were recorded at each setting of the horizontal tail.

2.2.1.3 Results

The results are summarized graphically in Figures 32 through 39 , Appendix I.

2.2.1.4 Quantitative Engineering Analysis

2.2.1.4.1 Static Longitudinal Trim Stability

2.2.1.4.1.1 General

The static longitudinal trim stability is determined from the control positions required to maintain a trimmed level flight condition from hover to maximum airspeed obtained during FM flight. The longitudinal control introduces moment changes from the pitch fan and from a conventional elevator. These moments are used to balance the pitching moments from the wings, wing fans and horizontal stabilizer. During hovering flight and low airspeeds the aerodynamic control moments are small and trim is primarily accomplished by the pitch-fan control. The fan pitching moments and longitudinal control required for trim are changed by airspeed and the variation in power required for level flight. Aerodynamic pitching moments from the elevator and horizontal stabilizer become more effective with increased airspeed and the authority of the pitch-fan control is phased out.

The conventional elevator deflection is directly proportional to the longitudinal stick movement, and the pitch-fan door movement per inch of control is varied with the vector angle. This variation is programmed automatically and is such that the pitching moment per inch of stick input is decreased as airspeed is increased. These characteristics are illustrated in Figure 23 Appendix I .

The longitudinal stick forces result from the longitudinal control force trim package and aerodynamic feedback from the conventional elevator. The force trim package provides a positive trim force with stick motion. The force gradient changes with the vector angle. This force gradient/vector angle relationship is shown in Figure 1 , Appendix I . The elevator forces vary with airspeed and are most significant at high airspeeds when the aerodynamic forces are greatest and the control force gradient from the trim system is weakest.

2.2.1.4.1.2 Longitudinal Stick Trim Position

The longitudinal trim stability was positive (forward stick displacement required for increased airspeed) from a hover to 50 KCAS. The stick moved forward 2.5 inches over this airspeed range. The static stability was neutral at 50 KCAS and became negative for all higher airspeeds. The control moved 2.5 inches aft as airspeed was increased from 50 to 95 KCAS. The stick position reversal was gradual, with no sharp discontinuities. The

position of the landing gear did not affect the longitudinal trim stability.

Changing the angle of attack from -2 to +5 degrees required no change in stick position. The change in pitching moment was illustrated by the change in the pitch-fan door position. This variation in pitch-fan door position was programmed automatically as the vector position was changed and adequately compensated for the pitching moment variations. The vector position, airspeed, and angle-of-attack data showed that at a given airspeed, the vector angle had to be increased approximately 1.5 degrees for each degree of increased angle of attack. This relationship was essentially constant for an airspeed range from zero to 95 KCAS and angles of attack from -2 to +5 degrees.

Increasing airspeed 1 knot required approximately .5-degree change of vector angle. The vector required for airspeed change at constant angle of attack was essentially the same for angles of attack from -2 to +5 degrees and from 25 to 95 KCAS. Below 25 KCAS, a slight nonlinearity was noted in the vector/airspeed relationship for all angles of attack investigated. Recommendation 1.7.2f

The horizontal stabilizer position was fixed at the maximum leading-edge-up position of 20 degrees for all vector angles below 30 degrees. This provided a maximum nose-down pitching moment from hover to 75 knots (zero-degree angle of attack). From zero to 55 KCAS the pitching moment contributed by the stabilizer was insufficient and additional nose-down control was provided with forward stick. Above 55 KCAS, the stabilizer was at the maximum leading-edge-up position, and the nose-down moment increased rapidly with airspeed. This nose-down moment was in the unstable direction and contributed to the negative trim stability at high speeds. This was illustrated by an improvement in stability above 76 KCAS when the moment was decreased by trimming the stabilizer leading edge down and the aft longitudinal stick requirement was significantly decreased. Recommendations 1.7.2d, f

2.2.1.4.1.3 Longitudinal Stick Trim Forces

The longitudinal force trim package had insufficient authority between 32 and 72 KCAS. It was necessary to apply an untrimmed forward force to maintain stable level flight. The maximum untrimmed force was 7 pounds at 55 KCAS. The insufficient longitudinal trim authority was undesirable and should be corrected. Recommendation 1.7.2f

2.2.1.4.1.4 Horizontal Stabilizer Trim Effectiveness

The horizontal stabilizer was effective as a trim device for vector angles greater than 30 degrees. Trimming the stabilizer leading edge down decreased the aircraft pitch-down moment and reduced the aft stick requirement. Both elevator position and pitch-fan door position were affected by the stabilizer position.

At a trim airspeed of 90 KCAS, approximately .33 inches of aft stick were required for each degree of leading-edge-up stabilizer trim. Test data indicated that a full leading-edge-up stabilizer condition could be trimmed with the aft stick available. The test conditions were relatively static, with no delay between trimming the stabilizer and correcting with longitudinal stick. The control margin may be significantly reduced for a dynamic condition such as a runaway stabilizer with delayed corrective action.

The trim stick forces were positive, with a gradient of 6.5 pounds/inch of stick travel. Approximately 40 pounds of push force would be required for the maximum stabilizer trailing-edge-up condition.

A runaway horizontal stabilizer condition was simulated at an airspeed of 80 KCAS. There was insufficient longitudinal moment from the pitch fan and elevator to overcome the nose-down pitching motion with the horizontal stabilizer at 5.0 degrees trailing edge up. A graphic time history is presented in Figures 38 and 39, Appendix I.

2.2.1.4.1.5 Vector Trim Effectiveness

Changing the vector angle from a trim condition introduced pitching moments which resulted from both direct and indirect effect of the louver loads, wing, and fan-induced changes including flap effectiveness and horizontal stabilizer downwash. Maintaining a constant angle of attack during vectoring resulted in an airspeed change. This airspeed variation changed the pitching contributions from the wings, fans, stabilizer, and elevator. Longitudinal stick was applied to balance the moments and maintain level attitude. Longitudinal stick forces resulted primarily from the control system trim package at low speed and from the conventional elevator aerodynamic feedback at high speed.

A vector change of 16 degrees at a trim airspeed of 75 KCAS required 3.2 inches of longitudinal stick input. This could have been reduced approximately 1 inch by using horizontal

stabilizer trim. The control requirements followed the stick trim stability curve with similar areas of positive trim stability at low speeds and negative characteristics at high speed.

Longitudinal control forces introduced with vector changes were most significant at high speeds. At an airspeed of 75 KCAS, 10 degrees of aft vector change resulted in requirement for 10 pounds of push force to maintain a constant attitude.

2.2.1.4.2 Static Lateral Trim Stability

2.2.1.4.2.1 General

The static lateral trim stability is determined from the control positions required to maintain a trimmed level flight condition from hover to maximum FM flight speed. The lateral control introduces moments from spoiling and unspoiling of wing-fan lift accomplished by differential beta stagger ($\Delta\beta_S$) and from conventional ailerons. These moments are used to balance the rolling moments encountered during hover and low speed flight.

The aerodynamic control surface effectiveness is low and the trim is primarily accomplished using rolling moments from the wing fans. The wing-fan control effectiveness contribution to the total control is changed by airspeed as well as the variation in the power required to maintain level flight. Aerodynamic rolling moments from the ailerons also become more effective with increasing airspeed and the FM controls are phased out.

The conventional aileron deflection is proportional to the lateral stick movement, and the differential beta stagger per inch of control varies with the vector angle. This variation is programmed automatically so that the rolling moment per inch of stick input is decreased as airspeed is increased. These characteristics are illustrated in Figure 25 , Appendix I.

The lateral stick forces result from the combined inputs of the lateral control force trim package and the conventional aileron trim tab. The force trim package provides a positive trim force with a corresponding stick motion. The force gradient of the trim package changes with the vector angle. This force gradient/vector angle relationship is shown in Figure 8 Appendix I. Lateral stick forces resulting from the aileron trim tab are most significant at the high airspeeds when the control force gradient from the trim system is weak.

2.2.1.4.2.2 Lateral Stick Trim Positon

The lateral trim stability was nonlinear with airspeed. A constant right lateral stick displacement of .5 inches was required as airspeed was increased from 30 to 47 KCAS. This right lateral stick requirement then reversed and, at 80 KCAS, .3 inches of left stick were necessary to maintain wings-level flight. The lateral stick requirement was gradual with no abrupt discontinuities. This lateral stick variation resulted from the unsymmetrical phase-out of differential beta stagger ($\Delta\beta_S$) schedule as beta vector was varied. The trim data showed no $\Delta\beta_S$ present since the pilot had removed any $\Delta\beta_S$ with the lateral stick input. The use of $\Delta\beta_S$ as roll control was ineffective as beta vector was increased above 30 degrees. Recommendation 1.7.2c

Considerable scatter was found in the lateral control stick position data. Most of this scatter was caused by the free play in the differential beta stagger control system. The magnitude of this control free play was approximately ±.25 inches about the trimmed stick position. The inflight test data agreed generally with the data obtained during ground test.

Changing the angle of attack from -2 to +5 degrees required little change in lateral stick position.

2.2.1.4.2.3 Lateral Stick Trim Forces

The lateral control forces encountered during FM flight could be trimmed at all conditions.

2.2.1.4.3 Static Directional Trim Stability

2.2.1.4.3.1 General

The static directional trim stability is determined from the pedal control position required to maintain a constant angle of sideslip from hover to maximum airspeed in FM flight. The directional control introduces yawing moments from differential wing-fan vectored thrust and from a conventional rudder. These moments are used to balance the yawing moments encountered during flight. The aerodynamic moments are small at hover and during low-speed flight; therefore, the trim control is primarily derived from yawing moments obtained from the wing-fan vectored thrust. These wing-fan yawing control moments are changed by airspeed and power. The yawing moment contributed by the rudder becomes more effective with increasing airspeed and the fan controls are phased out.

The conventional rudder deflection is directly

proportional to the directional pedal movement, and the differential beta vector per inch of control varies with the vector angle. This variation of differential beta vector is programmed automatically so that the yawing moment per inch of pedal input decreases as vector angle is increased. The characteristics are illustrated in Figure 28, Appendix I.

The directional pedal trim forces result from the inputs by the directional control force trim package and the air loads on the rudder surface. The force trim package provides a positive gradient with the corresponding pedal motion. The directional force gradient changes with the vector angle. This force gradient/vector angle relationship is displayed in Figure 15, Appendix I. The directional forces attributed to the aerodynamic loads on the rudder increase with increasing airspeed.

2.2.1.4.3.2 Pedal Trim Position

The directional control requirement was linear as a function of airspeed with increasing left pedal required as airspeed was increased. The pedal position varied linearly from zero inches to .4 inches left from hover to an airspeed of 87.5 KCAS. The amount of differential beta vector varied from zero degrees at a hover to 2.0 degrees left at 87.5 KCAS. This pedal variation with airspeed was attributed to an unknown position error in sideslip indications and/or differences in the drag or vectored thrust contributions from the wing fans. The use of differential beta vector as a directional control was phased out as beta vector was increased above 35.5 degrees.

An excessive amount of free play was encountered in the differential beta vector control system. The magnitude of this condition was approximately ±.25 inches about the trim pedal position. The data obtained during ground tests generally agreed with the inflight test data.

2.2.1.4.3.3 Pedal Trim Forces

The pedal trim forces encountered during FM flight varied from 7 pounds right in hover to 6 pounds left at an airspeed of 87.5 KCAS.

2.2.1.5 Pilot Qualitative Comments (Pilot Opinion Rating: 3.5)

2.2.1.5.1 Static Longitudinal Trim Stability

The static longitudinal trim characteristics shown in Figure 32 , Appendix I, were not objectionable. The stick

reversal was sufficiently gradual and small in magnitude so that no difficulty was experienced during fairly large speed changes. In the speed range from 40 to 80 knots at zero-degree angle of attack, it was not possible to trim out forward stick forces. The lack of adequate forward longitudinal trim authority was a distracting characteristic and should be corrected. Recommendation 1.7.2f

2.2.1.5.2 Horizontal Stabilizer Trim Effectiveness

At speeds between approximately 20 and 60 knots the horizontal trim system was selected full aircraft nose down to provide trim or near trim. The horizontal stabilizer was controllable by the trim switch at a beta vector angle of 27 degrees or greater. The aircraft could be accelerated to conversion speed without trimming the stabilizer away from the 20-degree trailing-edge-down position. However, the trim rate was satisfactory for trimming out the forces during acceleration. At 90 knots a stabilizer setting of approximately 15 degrees trailing edge down trimmed the forces for zero-degree angle of attack. Runaway trim to the stabilizer full trailing-edge-up condition would involve a longitudinal push force in excess of 50 pounds and extrapolated data indicated insufficient stick authority at full engine power.

2.2.1.5.3 Vector Trim Effectiveness

Changes in trim due to vector angle changes were easily corrected by longitudinal stick and the trim rate was satisfactory for re-trimming within the authority of the system.

2.2.1.5.4 Static Lateral Trim Stability

Static lateral trim stability was satisfactory. Lateral trim requirements appeared essentially constant and linear in flight, with few or no corrections required by the pilot to maintain level balanced flight. The lateral trim rate during either JM or FM flight provided ample trim capability.

2.2.1.5.5 Static Directional Trim Stability

Static directional trim stability characteristics were satisfactory. Inflight directional trim changes for balanced flight were negligible and only occasional trim adjustments were required.

2.2.2 FAN-MODE STATIC LONGITUDINAL STABILITY

2.2.2.1 <u>Objective</u>

The objective of these tests was to evaluate the static longitudinal stability as a function of airspeed, angle of attack, and vector angle.

2.2.2.2 Method

The static longitudinal stability was evaluated by trimming the aircraft at the desired airspeed and angle of attack. The airspeed was varied by use of the longitudinal control while engine power, control force trim, and vector angle were maintained constant. At each stabilized point the control positions, control forces, and aircraft attitudes were recorded.

2.2.2.3 Results

The test results are presented graphically in Figures 40 through 41 , Appendix I.

2.2.2.4 Quantitative Engineering Analysis

2.2.2.4.1 Static Longitudinal Stability

2.2.2.4.1.1 General

The stick-fixed static longitudinal stability is determined from the longitudinal control position required to balance the change in pitching moments as airspeed is varied from trim. The change in pitching moment is caused by the horizontal stabilizer, change in wing and fan center of lift, and the variation in thrust from the wing and pitch fans with angle of attack and airspeed. The magnitude and direction of these moment changes depend upon the initial trim speed, the speed change from trim, and the angle-of-attack variation. The degree of stability is strongly influenced by the variation of pitch-fan door position with vector angle. At low vector angles the pitch-fan door motion per inch of longitudinal stick input is greatest and decreases with higher vector angles. This control system characteristic is shown in Figure 23, Appendix I. The aerodynamic loads on the conventional elevator provide moments in the same direction as the pitch-fan door. At high vector angles, the use of the pitch fan as a longitudinal control device is phased out and longitudinal control is obtained primarily from the elevator.

The stick-free static longitudinal stability is influenced by both the control force trim system and the aerodynamic forces from the conventional elevator. At low speeds the force system provides positive force gradients but the elevator is relatively ineffective. The stick force trim system varies the

force gradient with vector angle. The gradient is highest at low vector angles and is phased out as vector angle is increased. In areas where the force trim gradient is low, the elevator is effective and contributes control forces. The resulting stick-free stability is a function of the trim airspeed, direction of stick displacement, and magnitude of stick displacement from trim.

2.2.2.4.1.2 Stick-Fixed Longitudinal Stability

The stick-fixed longitudinal stability was positive (forward stick displacement required with increased airspeed) for airspeeds from 32 to 45 KCAS. For this flight regime, the horizontal stabilizer contribution was small and the stability was primarily influenced by the pitching moment variation from the fans. From 32 KCAS, the stability decreased with airspeed and became neutral at 45 KCAS. At trim airspeeds greater than 50 KCAS the stability was negative and reached a maximum negative value at 74 KCAS. At this trim airspeed, an unstable nose-down moment from the horizontal stabilizer resulted from an airspeed increase. Nose-up pitching moments from the pitch-fan door and the elevator (aft longitudinal stick) were required to oppose the stabilizer forces. The stability at increased airspeeds above a given trim point was generally nonlinear. The degree of nonlinearity increased with the magnitude of the change from trim. Recommendation 1.7.2d

Data obtained at 5-degree positive angle of attack at 74 KCAS was slightly more negative than that recorded for a zero-degree angle of attack.

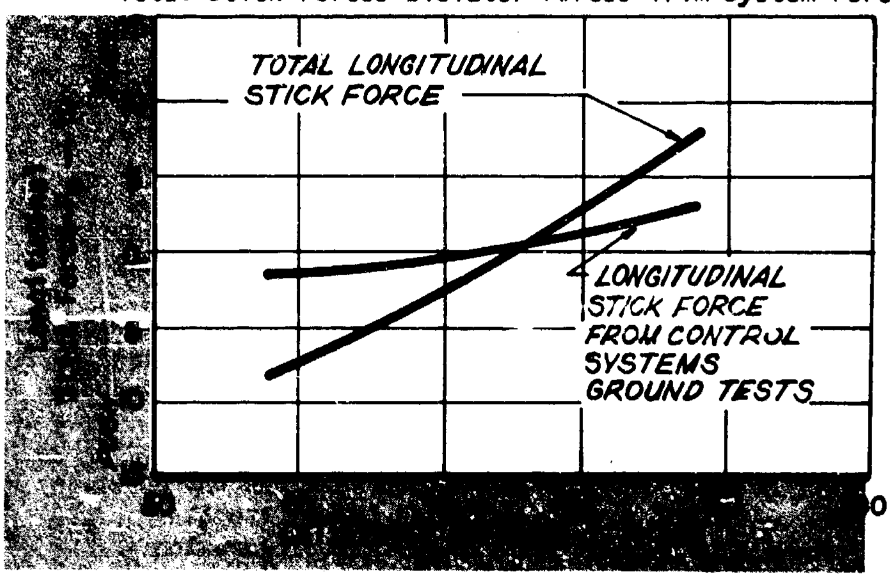
2.2.2.4.1.3 Stick-Free Longitudinal Stability

The stick-free longitudinal stability was positive (push force required to increase airspeed) at 32 KCAS. The positive stick-fixed stability required positive stick displacement with resulting positive stick forces. As airspeed was increased, the elevator contribution became more significant. Test data obtained during flight was compared with the control force data taken during the ground tests when only the control force trim system was operating. The difference between the flight data and the static data was essentially the result of elevator aerodynamic forces. This comparison is illustrated in Figure A .

FIGURE A
ELEVATOR AND TRIM SYSTEM FORCES

Trim Airspeed=75 KCAS Gross Wt = 10000
Landing Gear Down Collective Stick
Pressure Alt = 5000 Position = 100% (Up)

Total Stick Forces=Elevator Forces+Trim System Forces



The stick-free stability derivative was positive to an airspeed of 53.5 KCAS. Beyond this airspeed, the stability became negative and reached a maximum negative value of 0.51 pounds/knot at 74 KCAS. Increasing the trim angle of attack resulted in a more negative stick-free stability than for the zero-degree angle-of-attack tests. Recommendation 1.7.2d

2.2.2.5 Pilot Qualitative Comments

2.2.2.5.1 Static Longitudinal Stability

Negative stick-fixed and stick-free static longitudinal stability existed at airspeeds greater than 45 KCAS, reaching a maximum negative value at 74 KCAS. Due to the insufficient longitudinal trim authority in this region, "stick feel" was not the prominent factor to the pilot for airspeed control during fan-powered flight. The negative stability characteristics did, however, contribute to the requirement for careful pilot technique during any aircraft configuration changes within this flight regime, i.e., climbs and descents, speed and power. A pilot opinion rating of 3.5 was assigned to the static longitudinal stability characteristics in FM configuration. Recommendation 1.7.2d

2.2.3 FAN-MODE STATIC DIRECTIONAL STABILITY AND EFFECTIVE DIHEDRAL

2.2.3.1 Objective

The objective of the static directional tests was to determine the static directional stability and the effective dihedral throughout the FM flight envelope.

2.2.3.2 Method

The static directional stability and effective dihedral were measured by recording the control force, control displacement and resulting bank angle required to produce a given amount of sideslip angle. Pedal-fixed and pedal-free static directional stability were determined by relating pedal position, pedal force and sideslip angle. Stick-fixed and stick-free effective dihedral were determined from the lateral stick displacement and force relationship with sideslip angle.

2.2.3.3 Results

Test results are presented graphically in Figures 42 through 47 , Appendix I.

2.2.3.4 Quantitative Engineering Analysis

2.2.3.4.1 Static Directional Stability

2.2.3.4.1.1 General

The pedal-fixed static directional stability characteristics are influenced by moments from the vertical stabilizer and the pitch-fan momentum drag. The yawing control moments are obtained from the fan controls and the conventional rudder surface. The pitch-fan momentum drag tends to yaw the aircraft away from the relative free airstream. This constitutes a destabilizing moment which increases with the angle of sideslip. A positive stability moment is contributed by the vertical stabilizer. This positive moment increases with airspeed. The differential vector input with pedal displacement decreases with increasing vector angle. Since vector angle essentially determines airspeed, the result is a decreased fan yawing moment per inch of pedal input as the airspeed becomes greater. This control characteristic is illustrated in Figure 28 , Appendix I. The conventional rudder surface produces yawing moments which are additive to the fan control yawing moments. These moments are relatively small at low speeds, then increase with airspeed and become the primary directional control as the fan controls are phasedout.

The pedal-free static directional stability characteristics are determined by a control force trim system as well as conventional forces from the rudder. The control force trim system varies the pedal force gradient as the vector angle is changed. Aerodynamic forces of the rudder surface are also sensed in the pedals and these forces increase with airspeed. The total force required to achieve a sideslip angle is the sum of the two inputs.

2.2.3.4.1.2 Pedal-Fixed Directional Stability

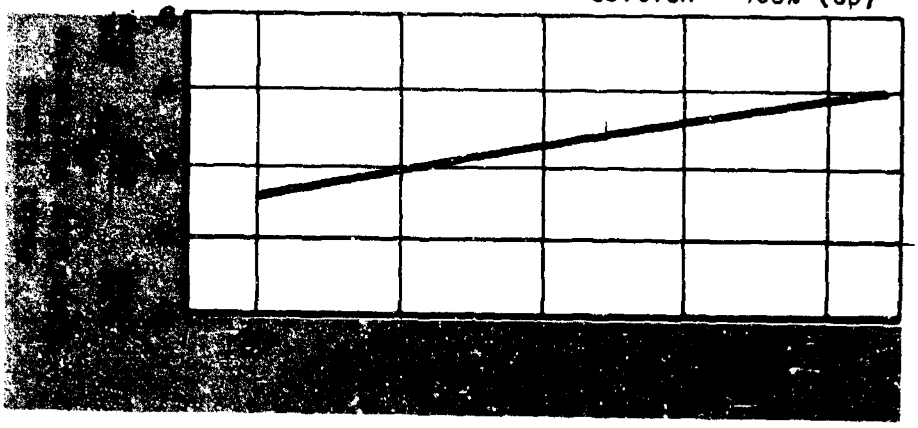
The pedal-fixed directional stability ($d\delta_{sr}/d\beta$) was positive (more opposite pedal with increasing sideslip angle) for all airspeeds above 30 KCAS. Stability characteristics from hover to 30 KCAS are presented in Sideward and Rearward Flight Stability, Paragraph 2.2.4. The stability was slightly positive and nonlinear at 30 KCAS. This nonlinearity resulted from the increased pitch-fan destabilizing moment as the sideslip angle was increased from trim. The vertical stabilizer and side force contributions were weak and, as a result, large sideslip angles could be obtained with small pedal inputs. The change in stability characteristics varied linearly with airspeed from .12 inches/degree at 30 KCAS to .4 inches/degree at 74 KCAS. As airspeed was increased from 30 KCAS, the pedal-fixed stability increased linearly with airspeed. This increased stability was caused by both the stability characteristics and the control system functions. Stable moments from the vertical stabilizer increased with airspeed and more directional control was required to yaw the aircraft. The fan yawing control contribution was decreasing with airspeed while the rudder control was increasing with airspeed.The net yawing control, however, did not increase as rapidly as the stability moments and increasingly positive directional stability resulted. The pitch-fan momentum drag stability contribution was less significant at high speeds and the stability was linear with sideslip angle at 74 KCAS. Recommendation 1.7.3d

2.2.3.4.1.3 Pedal-Free Directional Stability

The pedal-free directional stability was positive (pedal push force opposite the sideslip angle) for all airspeeds. At 30 KCAS, the rudder forces were low; however, the positive pedal displacement required resulted in positive pedal force with sideslip angle. As the airspeed was increased from 30 to 45 KCAS by more aft vector angles, the trim system force gradient was reduced. The stability decreased to a minimum at an airspeed of 45 KCAS. Above this airspeed, the increased forces from the rudder surface compensated for the decreased trim system force and provided a greater stability gradient $dF_r/d\beta$ with airspeed. The pedal-free stability characteristics are illustrated in Figure B .

The contractor-established sideslip envelope presented in Figure 4, Appendix IV was evaluated during the test program. The test data indicated that for a zero-degree angle of attack, no aerodynamic or control limits existed for this envelope. In these tests, however, each axis was evaluated separately and flight characteristics for the combined axes limits (maximum angle of

FIGURE B
SUMMARY OF FAN MODE PEDAL FIXED
STATIC DIRECTIONAL STABILITY



attack and sideslip angle simultaneously) were not investigated. Recommendation 1.7.3d

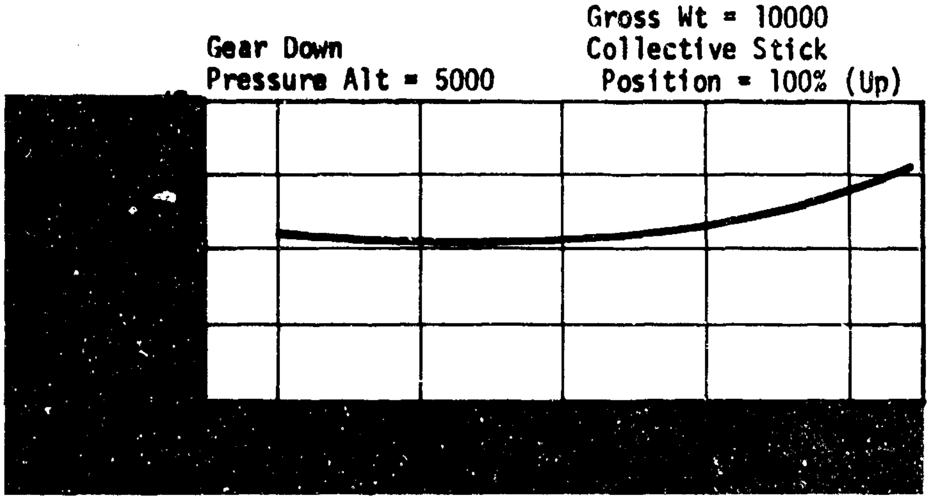
2.2.3.4.2 Effective Dihedral

2.2.3.4.2.1 General

The stick-fixed effective dihedral characteristics are determined by the rolling moment from the lateral control system and the aerodynamic moments from the wing fans, fuselage, wing and empennage. The complementary roll with yaw is designed to oppose any adverse rolling moment due to fan yaw control. The absence of adverse moment tends to produce positive effective dihedral at low speeds when the wing is ineffective. This is accomplished by introducing a differential fan thrust as pedal is used for directional control. At higher airspeeds when the wing becomes more effective, the control moment is phased out and dihedral is provided by the wing rolling moment with sideslip angle. The rolling moment characteristic contributed by the fan control system is illustrated in Figure C.

The lateral control forces from the control force trim system primarily establish the stick-free dihedral characteristics. Lateral control forces from the conventional aileron surfaces are small since only a trim tab is actuated by a lateral input. The control force system causes a change in the lateral stick force gradient as increased vector angle is used to obtain higher airspeeds. This characteristic introduces changes in the

FIGURE C
SUMMARY OF FAN MODE PEDAL FREE
STATIC DIRECTIONAL STABILITY



stability with airspeed which are independent of any aerodynamic moment changes that may occur.

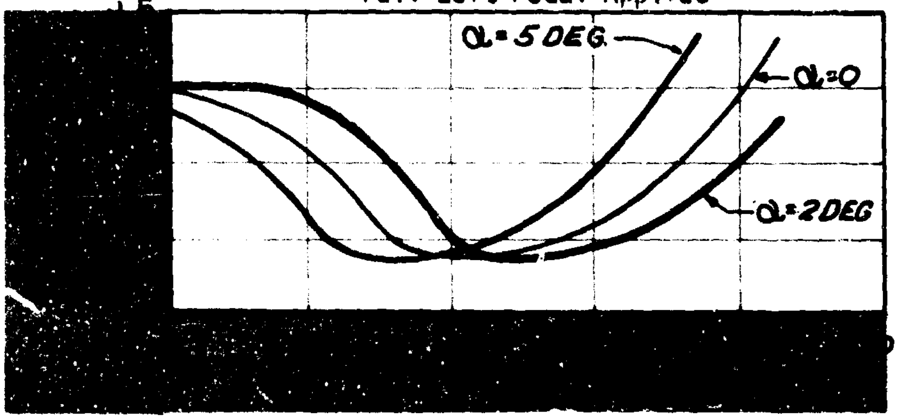
2.2.3.4.2.2 Stick-Fixed Effective Dihedral

The rolling moment per inch of pedal input at 30 KCAS was greatest at positive angles of attack and decreased as angle of attack became smaller. At 40 KCAS the control position was the same for all angles of attack. As the speed increased above 40 KCAS, the programmed control input decreased for all angles of attack.

The stick-fixed effective dihedral was positive (lateral stick displacement opposite pedal displacement) for all airspeeds from 30 to 74 KCAS. The variation in stability gradient ($d\delta_{s_a}/d\beta$) as a function of airspeed is presented in Figure D. For airspeeds of 30 to 40 KCAS, the rolling control input with pedal was constant and, since aerodynamic moments were small, the effective dihedral was essentially the same for these speeds. As airspeeds was increased above 40 KCAS the rolling moment input with pedal was programmed out. The rolling moments from the fans and the wing became increasingly effective with airspeed, and the stability gradient ($d\delta_{s_a}/d\beta$) increased from 0.1 to 0.3 inches/degree as airspeed was changed from 40 to 74 KCAS.

FIGURE D
DIFFERENTIAL STAGGER VARIATION
WITH AIRSPEED

Collective Stick Position = 100% (Up)
Full Left Pedal Applied



The stick-fixed effective dihedral was linear with sideslip angle for all airspeeds. Increasing lateral control input was required with increased sideslip angle.

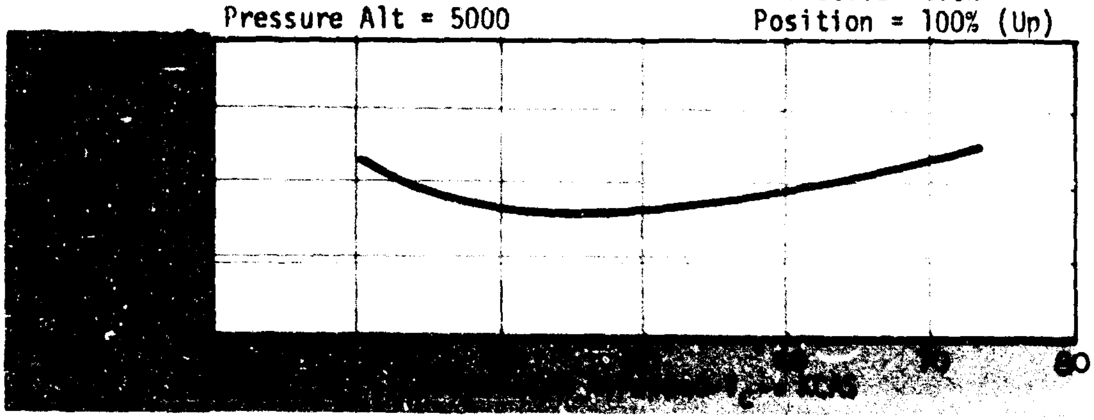
2.2.3.4.2.3 Stick-Free Effective Dihedral

The stick-free effective dihedral was positive (lateral stick force opposite pedal force) for all airspeeds from 30 to 74 KCAS. The stability increased from 30 KCAS and reached a maximum at an airspeed of 48 KCAS. This increase in stability was quite small; however, the trend was not anticipated. Trim system control force gradient was decreasing with airspeed, while the stick-fixed effective dihedral was also decreasing. Both of these characteristics contributed to a lower lateral stick force per degree of sideslip angle. The increase was attributed to the trim tab forces which were evidently contributing a stable moment. As the airspeed was increased, the trim system control force continued to decrease while the trim tab forces increased, and the resulting stick-free effective dihedral was slightly decreased with airspeed above 50 KCAS. At 75 KCAS, the stability was the same as at 30 KCAS. The stick-free effective dihedral characteristics are presented in Figure E .

FIGURE E
SUMMARY OF FAN MODE STICK FIXED
EFFECTIVE DIHEDRAL

Gross Wt = 10000
Collective Stick
Position = 100% (Up)

Gear Position = Down
Pressure Alt = 5000



2.2.3.5 <u>Pilot Qualitative Comments (Pilot Opinion Rating: 3)</u>

2.2.3.5.1 Fan-Mode Static Directional Stability and Effective Dihedral

Steady sideslips in FM configuration exhibited positive directional stability and positive dihedral effect throughout the 30-KIAS to 90-KIAS airspeed range. Control inputs, characterized by light forces at the lower airspeeds, were symmetric. Results of this portion of the testing are shown in Figures 42 through 47 Appendix I. As might be expected, in view of these low forces, steady-state sideslips were difficult to maintain at airspeeds below 60 KIAS. At these lower airspeeds the aircraft tended to yaw indiscriminately about the desired sideslip angles. This characteristic became more prominent as airspeed was reduced. These results were more of a nuisance-type shortcoming than objectionable in the accomplishment of the aircraft's primary research mission. An interesting phenomenon was the apparent performance increase observed during sideslips in FM configuration. With no change other than increased sideslip angle, the aircraft developed an increased rate of climb. A pilot opinion rating of 3 was assigned to the static lateral-directional stability characteristics observed in FM configuration during these tests. Recommendation 1.7.3d

2.2.4 FAN-MODE SIDEWARD AND REARWARD FLIGHT STABILITY

2.2.4.1 Objective

The objective of the sideward and rearward flight test was to determine the static trim stability and control margins while hovering in winds.

2.2.4.2 Method

Crosswind and tailwind hovering conditions were simulated by flying the aircraft sideward (left and right) and rearward in calm air. A calibrated pacer vehicle was used to record speed as the aircraft was stabilized at various ground speeds. Control positions, control forces and aircraft attitudes were recorded at each stabilized speed.

2.2.4.3 Results

The results are summarized graphically in Figures 48 and 49, Appendix I.

2.2.4.4 Quantitative Engineering Analysis

2.2.4.4.1 Sideward Flight

2.2.4.4.1.1 General

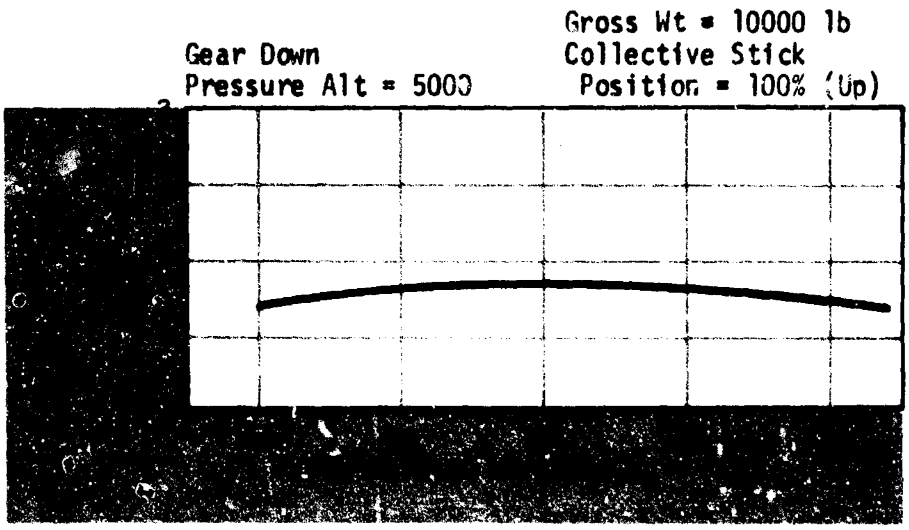
The sideward flight stability is determined by the amount of stick and pedal required to balance the changing moments about each axis as speed is varied in either direction. The major changes in these moments with increased airspeed are attributed to the variation in the pitch-fan and wing-fan momentum drag change in the center of aerodynamic sideload on the aircraft, vertical stabilizer, and change in lateral center of wing, body, and fan lift. These moments are balanced by vectored and modulated thrust from the wing and pitch fans and aerodynamic loads on the rudder surface. The magnitude and effectiveness of these moments are dependent on the direction and speed of the translation.

2.2.4.4.1.2 Static Directional Trim Stability

The directional control requirement was nonlinear with control reversals occurring during lateral translations both to the right and to the left. From trimmed hover to 11.5 knots, the directional trim stability was nonlinear and negative with right pedal required for right lateral translation and left pedal required for left lateral translation. A reversal occurred in the

directional control requirement at a speed of 11.5 knots, and the stability was positive for all speeds up to the maximum tested of 24.5 KCAS.The directional trim stability characteristics are presented in Figure F .

FIGURE F
SUMMARY OF FAN MODE STICK FREE
EFFECTIVE DIHEDRAL



The directional instability occurring about the trimmed condition was attributed to the pitch-fan and engine-inlet momentum drag. At speeds below 11.5 knots the magnitude of this momentum drag was such that the resulting yawing moment tended to turn the aircraft downwind. Above 11.5 knots, the positive yawing moment from the vertical stabilizer and the side loads on the fuselage was of sufficient magnitude to cause a tendency for the aircraft to turn into the wind. Recommendation 1.7.2e

2.2.4.4.1.3 <u>Static Lateral Trim Stability</u>

The lateral trim stability was positive and slightly nonlinear over the speed range investigated. Increasing right lateral stick was required with increasing right lateral translation. The maximum stabilized bank angle obtained during the

test was 11 degrees at 24.5 knots to the left. The lateral trim stability characteristics are illustrated in Figure G.

FIGURE G
SUMMARY OF STATIC TRIM STABILITY
DURING SIDEWARD FLIGHT

Gear Down
Pressure Alt = 5000 • Gross Wt = 10000

2.2.4.4.1.4 <u>Longitudinal Control Requirements</u>

An increasing nose-up longitudinal pitching moment was encountered as the airspeed was increased in either direction from a stabilized hover. This condition dictated a requirement for increasing forward longitudinal control displacement to maintain the desired attitude.

2.2.4.4 2 Low-Speed Forward and Rearward Flight

2.2.4.4.2.1 <u>General</u>

The low-speed forward and rearward flight stability is determined by the longitudinal control required to balance

the change in pitching moments as speed is varied from hover. The change in pitching moments is attributed to the horizontal stabilizer and change in wing, body, and fan center of lift. The magnitude and direction of these pitching moments are dependent on vector angle, direction of flight, and airspeed. The change in pitching moment is balanced by the use of modulated thrust from the nose fan and aerodynamic moments from the elevator.

2.2.4.4.2.2 Static Longitudinal Trim Stability

The longitudinal trim stability during low-speed forward flight from a hover was positive with increasing forward stick required as speed was increased. A near level attitude during forward translation was maintained by the use of vector angle and longitudinal control. The longitudinal stick displacement was nonlinear with a slight discontinuity between 12.5 knots and 17 knots. The vector angle required to achieve the desired speed was also nonlinear with the largest change occurring between hover and 10 knots.

The longitudinal trim stability during rearward flight was positive and slightly nonlinear as speed was increased from hover. The vector angle was constant during rearward flight and the desired speed was achieved by application of longitudinal control. The aerodynamic loads on the horizontal stabilizer resulted in a nose-up pitching moment which increased with rearward speed. This nose-up pitching moment as rearward speed increased caused a reduction in aft longitudinal stick requirement and resulted in decreased trim stability. The stability was neutral at 18 knots.

2.2.4.4.2.3 Lateral and Directional Control Requirements

The lateral and directional control requirements during rearward flight were small. These small variations were caused by the nonlinearities in the differential beta stagger and differential beta vector schedule as a function of the vector angle.

2.2.4.5 Pilot Qualitative Comments

2.2.4.5.1 Sideward and Rearward Flight

The following comments are based upon one flight limited by the then existing sideward and rearward flight envelopes of 13 KCAS and 8 KCAS respectively. The test aircraft

exhibited positive stick-free lateral stability during both left and right sideward flight. To increase speed to either the left or right required increased lateral stick forces in the desired direction. Directionally the aircraft tended to yaw away from the direction of flight and required increasing corrective rudder forces as sideward airspeed was increased. In later contractor conducted tests, a rudder force reversal was observed at 12.5 knots. During rearward flight the aircraft exhibited positive stick-free longitudinal stability to the maximum KCAS rearward flight investigated. No objectionable flight characteristics were observed during these tests. A pilot opinion rating of 3.5 was assigned to the sideward flight characteristics of the XV-5A and a rating of 2.5 to the rearward flight characteristics. Recommendation 1.7.2e

2.2.5 FAN-MODE DYNAMIC STABILITY

2.2.5.1 Objective

The objective of these tests was to determine the dynamic stability characteristics of the XV-5A during FM flight.

2.2.5.2 Method

The dynamic stability characteristics were evaluated by recording the aircraft motions that resulted from pulse-type control inputs. All control inputs were conducted without the aid of a control (free hand). Each input was accomplished by rapidly displacing the control along the desired axis, holding the control in this position 1.0 second, then rapidly returning the control to the approximate trim control position. This trim position was then held until the aircraft stabilized or recovery action was necessary.

All tests were conducted with the stability augmentation system (SAS) on and operating at the contractor's recommended gain settings.

Aerodynamic and fan control position, aircraft attitudes and angular rates were recorded for each control input.

2.2.5.3 Results

Test results are presented graphically in Figures 50 through 65 , Appendix I.

2.2.5.4 Quantitative Engineering Analysis

2.2.5.4.1 General

The dynamic stability characteristics are determined by the damping moments contributed by the fans, wing, vertical and horizontal stabilizers, and SAS in addition to the static stability influences previously discussed. Damping from the fans about any axis is influenced by both the trim airspeed and power required characteristics. The change in relative inflow velocity and direction results in a different flow through the fans with attendant changes in damping. The conventional aerodynamic damping from the wings, vertical and horizontal stabilizers is sensitive to both airspeed rate and angle of attack. The SAS is the most significant contributor to the stability characteristics. The SAS senses a rate and applies an opposing moment by adjusting the pitch-fan door and wing-fan louver positions. The magnitude of the SAS input is dependent upon the magnitude of the rate. The direction of the input opposes the aircraft motion. For roll, an additional signal is put in from the quasi-integration of the rate. The SAS authority is constant for all FM flight conditions and the gain for controls centered remains constant. Although the SAS input per unit of rate is constant, the damping is not a constant value since pitch-fan door and wing-fan louver effectiveness vary with flight condition.

2.2.5.4.2 Dynamic Longitudinal Stability

The dynamic longitudinal stability characteristics were similar for all airspeeds and flight conditions evaluated. Any variations in stability characteristics with airspeed were masked by the strong SAS damping. Following an aircraft disturbance, the SAS immediately opposed any rate. The SAS lag was apparently less than the instrumentation lag and the time could not be established from the data.

The strong, sensitive SAS effectively damped the rate to zero within 1/2 cycle. A small characteristic over-shoot occurred but no residual oscillations were experienced. The attitude returned to trim and no significant airspeed changes were noted. No significant normal acceleration changes were present for pitch rate disturbances as high as 8 deg/second.

No apparent dynamic coupling was present during the tests, and at no time was the aircraft control-limited during the recovery maneuver.

The longitudinal dynamic stability in a hover with

the SAS off was heavily damped with the pitch rate being damped to zero within 1/2 cycle.

2.2.5.4.3 Dynamic Lateral-Directional Stability

A lateral disturbance resulted in a "deadbeat" to highly damped lateral oscillation for all speeds below 75 KCAS. In all cases the rate was damped to zero within one cycle. The strong SAS damping compensated for any variations in basic aircraft stability. At 85 KCAS the SAS was relatively ineffective, aircraft stability was weak and the rate was a lightly damped lateral oscillation with a period of 2 seconds. In all cases the resulting roll angles were small and the aircraft returned to trim attitude.

Directional coupling was present for all airspeeds. This coupling was small, highly damped and complementary to the rolling motion in all cases.

SAS off, a lateral pulse input in a hover resulted in a neutrally damped rolling oscillation. Lateral corrective control input requirements to the resulting aircraft motion were immediate and unpredictable in direction and in magnitude. These lateral inputs continued until the aircraft returned to a wings-level condition.

2.2.5.4.4 Dynamic Directional Stability

Dynamic directional stability was positive during hover. The rate was damped to zero within 1/2 cycle. The aircraft yawed in the direction of the disturbance, then stabilized at some new heading. A small adverse roll rate was experienced, but no apparent bank angle resulted.

The dynamic directional stability was positive in level flight. The strong SAS provided very high damping with resulting strongly positive stability at airspeeds from 30 to 52 KCAS. No significant lateral-directional coupling occurred. At 52 KCAS the motion was a lightly damped, complementary roll and yaw oscillation with a period of approximately 3 seconds. The aircraft returned to the trim within 2 cycles. This weak stability was caused by reduced SAS effectiveness and lack of aerodynamic damping. As airspeed was increased to 70 KCAS, stability improved. Although the SAS effectiveness decreased with speed, the aerodynamic surfaces became more effective and resulted in an overall improvement in the stability characteristic.

A directional disturbance with the SAS off during a

hover resulted in a heavily damped oscillation. The yawing motion was very similar to the SAS-on dynamic directional stability.

2.2.5.5 Qualitative Pilot Comments

2.2.5.5.1 Dynamic Longitudinal Stability

Within the alpha range of -2 to +5 degrees, longitudinal disturbances were well damped from hover to maximum FM speed although the initial trim attitude was not always re-established. A pilot opinion rating of 2 was assigned to these characteristics. Typically there was a small characteristic overshoot with no residual oscillations. Qualitatively the observed longitudinal disturbances were well damped over the entire fan-mode airspeed envelope. A pilot opinion rating of 2 was assigned to these characteristics.

2.2.5.5.2 Dynamic Lateral-Directional Stability

No coupling of lateral-directional oscillations existed as a result of pulse disturbances of the lateral or directional control in hovering flight. At speeds above 30 knots, lateral disturbances showed well damped rate response although the trim bank angle was rarely re-achieved. Lateral gust sensitivity was fairly high in turbulence and some over-control occurred. Directional disturbances at speeds above 30 knots caused an increasing amount of roll coupling. Pulse disturbances showed good rate damping; this was weakest in the mid speed range and strongest at 90 knots. Directional gust sensitivity was high and resulted in considerable lateral coupling. The safe flight attitudes were not difficult to maintain in turbulence, but accurate data acquisition was impossible even in light turbulence. In hovering flight the SAS system was extremely effective in compensating for either turbulent air or self-induced disturbances. Pilot control inputs were required only to adjust aircraft attitude for positioning over the ground. A pilot opinion rating of 3.5 was assigned to these characteristics.

2.2.5.5.3 Dynamic Directional Stability

The dynamic directional stability was positive in a hover. The aircraft yawed in the direction of the disturbance and then stabilized at some new heading.

The dynamic directional stability was positive in level flight with the SAS providing very high damping at airspeeds

between 30 and 49 KCAS. At 52 KCAS the motion was a lightly damped, complementary roll and yaw oscillation with a period of approximately 3 seconds. The weak stability was caused by reduced SAS effectiveness and lack of aerodynamic damping. As airspeed was increased to 70 KCAS the stability improved. A pilot opinion of 3 was assigned to these characteristics.

2.2.6 FAN-MODE CONTROLLABILITY (SAS ON)

2.2.6.1 Objective

The objective of the controllability tests was to determine the angular accelerations and rates that result per inch of control input during FM operation.

2.2.6.2 Method

The controllability was evaluated by recording the motions that resulted from step-type inputs. All control inputs were accomplished free hand without the aid of a control fixture. The step inputs were accomplished by rapidly displacing the control to the desired position, then holding this position until maximum rate was reached or recovery action was necessary. The magnitude of the step inputs was varied and the tests were conducted about each control axis.

All tests were conducted with the SAS on and operating at the contractor's recommended gain settings.

Aerodynamic and fan control positions, aircraft attitudes, and angular rates were recorded for each control input.

2.2.6.3 Results

Test results are presented graphically in Figures 66 through 85 , Appendix I.

2.2.6.4 Quantitative Engineering Analysis

2.2.6.4.1 Longitudinal Controllability

2.2.6.4.1.1 General

The longitudinal controllability characteristics are established by pitching moments from the control input and the opposing inertia and aerodynamic damping moments from the aircraft as well as the input from the SAS to the pitch-fan doors. A reduction in SAS rate gain occurs for longitudinal stick displace-

ment beyond approximately 1 inch from trim. The movement of the pitch-fan doors changes the pitch-fan thrust; this results in a pitching moment in the direction of the longitudinal control input. Since the pitch-fan door and longitudinal stick relationship is influenced by the vector angle, the resulting pitching moment per inch of control input decreases automatically with increased vector angle and changes the controllability characteristics. The conventional control system is operative and the elevator deflection per inch of longitudinal stick travel is linear and constant during FM flight. The elevator effectiveness increases with airspeed and provides longitudinal control moments which are additive to the pitch-fan moments.

2.2.6.4.1.2 Longitudinal Control Sensitivity

Longitudinal control sensitivity (maximum acceleration per inch of stick deg/sec^2/inch) occurred quickly and was primarily dependent upon the magnitude of the initial pitching moment and the aircraft moment of inertia. The initial pitching moment variation at low speed was most significantly influenced by the pitch-fan door/vector angle relationship. The pitching acceleration contribution of the elevator increased with increasing airspeed.

The longitudinal control sensitivity varied nonlinearly with airspeed. Maximum pitching acceleration was reached in approximately .35 seconds for all conditions tested. The magnitude of the longitudinal sensitivity in a hover varied slightly with collective stick position. The control sensitivity during hover at 30-percent collective was 6.0 deg/sec^2/inch and increased to 7.6 deg/sec^2/inch for a collective setting of 70 percent. This increase in acceleration may be caused by repositioning of the pitch-fan doors as collective stick was raised (Reference Figure 66, Appendix I).

The envelope limited level flight testing to airspeeds below 30 knots indicated airspeed (KIAS). The longitudinal controllability, therefore, was investigated between 43 and 70 KCAS with the gear down and the protective heat shield installed. The longitudinal sensitivity at 43 KCAS was 5.0 deg/sec^2/inch for an aft input and 6.0 deg/sec^2/inch for a forward input. The maximum acceleration per inch of stick then increased nonlinearly with speed and reached 14.6 deg/sec^2 for a forward input, and 13 deg/sec^2 for an aft control motion at an airspeed of 70 KCAS. The increase in acceleration with increasing airspeed was attributed to the greater elevator effectiveness.

2.2.6.4.1.3 Longitudinal Control Response

The longitudinal control response (maximum rate per

inch of stick input deg/sec/inch) was primarily dependent upon the rate damping of the SAS. Following the development of the rate, the SAS provided an opposing moment which tended to reduce the rate to zero. This opposing SAS input (degree/δ_{pfd}/deg/sec) to the pitch-fan control system was the same for all vector angles.

An initial angular velocity occurred within .1 second and was in the same direction as the control motion. The angular velocity then increased in a normal manner and became concave downward approximately .35 seconds following control input. The time required to reach the maximum rate was .70 seconds for all conditions tested. The aircraft was generally more responsive to a forward step then to an aft step for all conditions except a hover.

During a hover, the longitudinal response was the same for both a 30- and 70-percent collective setting. The magnitude of this response was 2.4 deg/sec/inch. The same maximum rate value for the two collective settings was attributed to the high SAS damping.

In level flight the control response was essentially the same from 43 to 70 KCAS. Although the acceleration per inch of stick increased with airspeed, the SAS response provided greater damping which prevented a rate buildup with airspeed.

The magnitude of the control response for this airspeed range was 3.0 deg/sec/inch for a forward step and 2.4 deg/sec/inch for an aft input.

2.2.6.4.1.4 Angular Pitch Displacement

Aerodynamic moments from the horizontal stabilizer aided the SAS in opposing the control input. The magnitude of these aerodynamic moments increased with airspeed.

The angular pitch displacement (deg/inch) was the same for hover and forward flight. In all cases the longitudinal control input caused a pitch attitude change in the proper direction. The angular displacement continued to increase until recovery action was necessary. The pitch displacement in a hover for 30- and 70-percent collective control (up) was 2 deg/inch at 1.0 second after control input. The angular pitch displacement between 43 and 70 KCAS was a constant 2.3 deg/inch for a forward input and 1.7 deg/inch for an aft step at 1.0 second following control input.

2.2.6.4.2 Lateral Controllability

2.2.6.4.2.1 General

The rolling moments from a lateral control input and the opposing inertia and aerodynamic damping moments from the aircraft establish the inherent lateral controllability. The total lateral controllability is also affected by the opposing rolling moments from the SAS inputs to the wing-fan louvers. Following a control input, the movement of the wing-fan louvers produces a differential thrust which results in a rolling moment in the direction of the lateral control input. The rolling moment per inch of control input attributed to the wing fans decreases as vector angle is increased. This decrease in fan rolling moment results from the wing-fan lateral controls' being phased out by the mechanical mixer box as vector angle is increased. The conventional control system is operative during FM flight and the aileron deflection per inch of lateral stick travel is constant. The rolling moment contributed by the aileron increases with increasing airspeed.

2.2.6.4.2.2 Lateral Control Sensitivity

Lateral control sensitivity (maximum acceleration per inch of stick deg/sec^2/inch) was primarily dependent upon the magnitude of the initial rolling moment and the aircraft moment of inertia. Peak acceleration occurred almost immediately and was not affected by rate of aerodynamic damping. The maximum rolling acceleration at low airspeeds was influenced by the wing-fan lateral control/vector angle relationship. The rolling moment resulting from the ailerons increased with airspeed.

The lateral control sensitivity was positive and nonlinear with airspeed variation. The same maximum acceleration was exhibited for both right and left lateral inputs. The lateral control sensitivity in a hover varied with collective stick position. The sensitivity was 12 deg/sec^2/inch at 30-percent collective and 17.7 deg/sec^2/inch for a 70-percent collective setting. The maximum control sensitivity in level flight occurred at 30 KCAS with a value of 18 deg/sec^2/inch. The angular acceleration then decreased with airspeed and reached a minimum sensitivity of 15 deg/sec^2/inch at 58 KCAS. This decrease in lateral sensitivity with airspeed was attributed to the phasing out of the FM lateral control while the ailerons were still not effective. Above 58 KCAS, the sensitivity then increased slightly to a value of 15.8 deg/sec^2/inch at 70 KCAS. This increase in rolling acceleration was attributed to the increased aileron effectiveness at speeds above 58 KCAS.

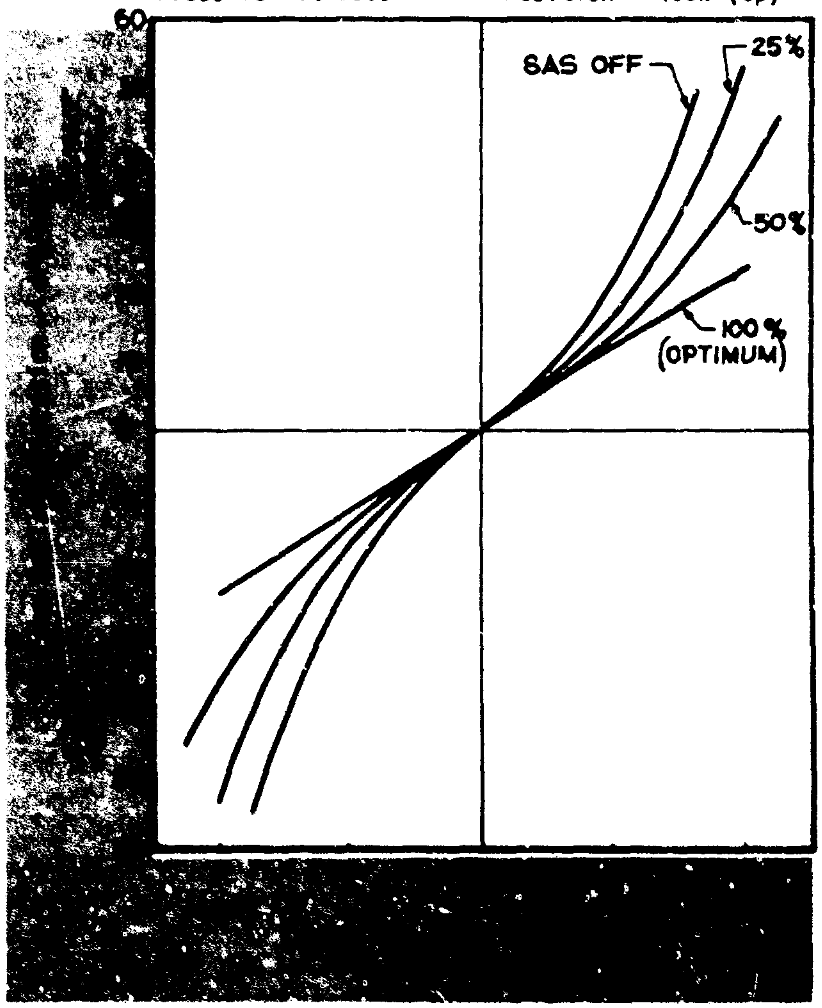
The maximum angular acceleration for a lateral step control input was reached in .4 seconds during hover and .35 seconds while in level flight.

The lateral control sensitivity in a hover for reduced SAS gains is presented in Figure H. The lateral control sensitivity increased as the SAS gain was decreased. This increase in acceleration was attributed to the decrease in SAS damping with smaller SAS gains.

FIGURE H
VARIATION IN LATERAL CONTROL SENSITIVITY
DURING HOVER WITH VARIOUS SAS GAINS

Wheel Ht. Above the Ground = 25 ft
Gear Down
Pressure Alt=5000

Gross Wt = 10000 lb
Collective Stick Position = 100% (Up)



2.2.6.4.2.3 Lateral Control Response

The lateral control response (maximum rate per inch of stick input deg/sec/inch) was primarily dependent upon the rate damping from the SAS. The SAS provided an opposing moment which tended to reduce any roll rate to zero. The opposing mechanical SAS input (degrees β_s/deg/sec) to the wing-fan control system was the same for any vector angle position. However, since wing-fan control effectiveness decreased with airspeed, the SAS response opposing the rate was also effectively decreased with increasing airspeeds. The aerodynamic damping from the aircraft also aided in reducing the roll rate as airspeed was increased. The SAS gain setting for fan-mode operations were the same for all flight conditions.

There was no excessive delay in the development of angular velocity in response to a lateral control input. The opposing SAS input was almost immediate after the roll rate was developed. The time required to reach maximum roll rate was approximately 1.0 second and the lateral control response was the same for both left and right control inputs.

The collective stick position had an effect on the lateral control response during a hover. With the collective stick at 30 percent of full up, the maximum roll rate was 4.0 deg/sec/inch, while a 70-percent collective setting produced 5.8 deg/sec/inch. This increased response resulted from the increased stagger effectiveness with collective stick position.

The control response for level flight at 30 KCAS was 6.5 deg/sec/inch and decreased slightly to 6.0 deg/sec/inch as airspeed was increased to 60 KCAS. As airspeed was further increased to 70 knots the maximum roll rate per inch of stick increased to 6.4 deg/second. This increase in response at higher speeds was caused by reduced SAS damping and increased aileron effectiveness.

A longitudinal-directional coupling (right yaw and a pitch-up following a right lateral step) was present for all flight conditions. This coupling became stronger as airspeed was increased

2.2.6.4.2.4 Angular Roll Displacement

The roll attitude resulting from a step input was determined by the magnitude of the rate and the time the rate was applied to the aircraft. Aerodynamic roll damping from the aircraft aided the SAS in opposing the control input. The magnitude

of these aerodynamic moments increased with airspeed.

The angular roll displacement (deg/inch at 1 second) resulting from a lateral step input occurred and was in the proper direction. The bank angle continued to increase until an opposing stick input was used for recovery. The roll displacement during a hover varied with collective control position. For a collective stick position of 30 percent bank angle reached was 1.7 deg/inch and for a collective position of 70 percent the roll displacement increased to 3.0 deg/inch. At an airspeed of 30 KCAS the angular roll displacement was 2.8 deg/inch and increased slightly to 3.3 deg/inch at an airspeed of 70 KCAS.

2.2.6.4.3 Directional Cont ollability

2.2.6.4.3.1 General

The directional controllability characteristics are established by the yawing moments from the pedal input and the opposing inertia and aerodynamic moments from the aircraft as well as the input from the SAS to the wing-fan louvers. The movement of the wing-fan louvers increases or decreases the horizontal thrust from each wing fan and results in a yawing moment in the direction of the pedal input. The yawing moment per inch of pedal input decreases with increasing vector angle. This decrease in yawing moment is caused by the mechanical mixer box which varies the wing-fan directional control with vector angle changes. The conventional directional control system is operative during fan-mode flight. The yawing moment from the rudder increases with airspeed.

2.2.6.4.3.2 Directional Control Sensitivity

Directional control sensitivity (maximum acceleration per inch of pedal deg/sec^2/inch) was primarily dependent upon the magnitude of the initial yawing moment and the aircraft moment of inertia. At low airspeeds the resulting maximum yawing acceleration was from a combination of wing-fan yawing control and vector angle relationship. The yawing moment from the aerodynamic rudder became predominant as rudder effectiveness increased with airspeed while the fan controls became progressively weaker with higher vector angles.

The directional control sensitivity was positive and nonlinear with airspeed. The angular acceleration was immediate and in the proper direction following a pedal input. The collective stick position affected the control sensitivity during hover. The magnitude of the sensitivity varied from 6 deg/sec^2/inch to

7 deg/sec^2/inch for a collective setting of 30 to 70 percent respectively. The minimum control sensitivity during level flight was 8 deg/sec^2/inch and occurred at an airspeed of 30 KCAS. In this area the low sensitivity was caused by the decreased yawing moment from the fan controls and relatively low rudder effectiveness. The yawing moments from the aerodynamic rudder predominated as airspeed was increased above 40 KCAS. This increased rudder effectiveness caused the control sensitivity to increase non-linearly with airspeed and reach a value of 10.5 deg/sec^2/inch at 70 KCAS. Recommendation 1.7.3e

The time required to reach maximum angular acceleration was .45 seconds in both directions for all forward flight conditions tested.

2.2.6.4.3.3 Directional Control Response

The directional control response (maximum rate per inch of stick input deg/sec/inch) was primarily dependent upon the rate damping from the SAS and the vertical aerodynamic stabilizer. The SAS provided an opposing moment which tended to reduce the yaw rate to zero. The opposing mechanical SAS input (degrees/deg/sec) to the wing-fan control system was the same for any vector angle position. Although mechanically the same, the SAS damping was effectively decreased with airspeed since wing-fan control effectiveness decreased with increasing vector angle. The aerodynamic damping from the aircraft also aided in reducing the yaw rate as airspeed was increased.

A directional step control input resulted in an immediate angular velocity in the proper direction. The opposing SAS input closely followed the yaw rate. The control response was the same for either a right or left step input.

The maximum directional control response in a hover could not be quantitatively measured. Although the pedal input was held for approximately 3 to 6 seconds, the yaw rate continued to increase with the maximum not occurring before recovery action was necessary. For this reason, the yaw rate was measured at 1 second after the control input. The angular velocity in a hover varied with collective control position. By increasing the collective from 30 to 70 percent, the maximum rate varied from 3.5 deg/sec/inch to 5.8 deg/sec/inch respectively. Recommendation 1.7.3e

The time required to obtain the maximum yaw rate in level flight varied from 1.4 seconds at 30 KCAS to .85 seconds between 55 and 70 KCAS. The maximum control response was 4.7 deg/

sec/inch at an airspeed of 30 KCAS. The higher directional damping from the vertical stabilizer decreased the maximum yaw rate as airspeed was increased above 30 KCAS. This increased damping resulted in a directional control response to 3.0 deg/sec/inch at 70 KCAS.

A longitudinal-lateral coupling was present for all level flight conditions. The resulting motion for a pedal step input was a yaw and roll in the direction of pedal input followed by a pitch up. The coupling became stronger as airspeed was increased.

2.2.6.5 Qualitative Pilot Comments

During hover operations above 10-foot wheel height with SAS at test settings (See Appendix I), the controllability characteristics were excellent. Results of dynamic steps and pulses about the 3 axes showed the SAS to be a very effective system. During hover operations below 10 feet an evaluation of controllability characteristics was not possible due to the problem area discussed in Paragraph 2.4.1.5. Although not quantitatively documented, there existed a severe degradation of lateral fan-mode control power with application of full-up lift stick. This lift-stick position - lateral control coupling characteristic was unsatisfactory and requires correction. The fan-mode controllability characteristics observed for the 30 KIAS - 80 KIAS airspeed range enhanced the XV-5A flying qualities. Some control looseness was noted in this regime; however, no objectionable characteristics were observed during this portion of the evaluation. A pilot opinion rating of 3 was assigned to the fan-mode controllability characteristics observed during this evaluation. Recommendation 1.7.3e

2.2.7 FAN-MODE AIRSPEED CALIBRATION

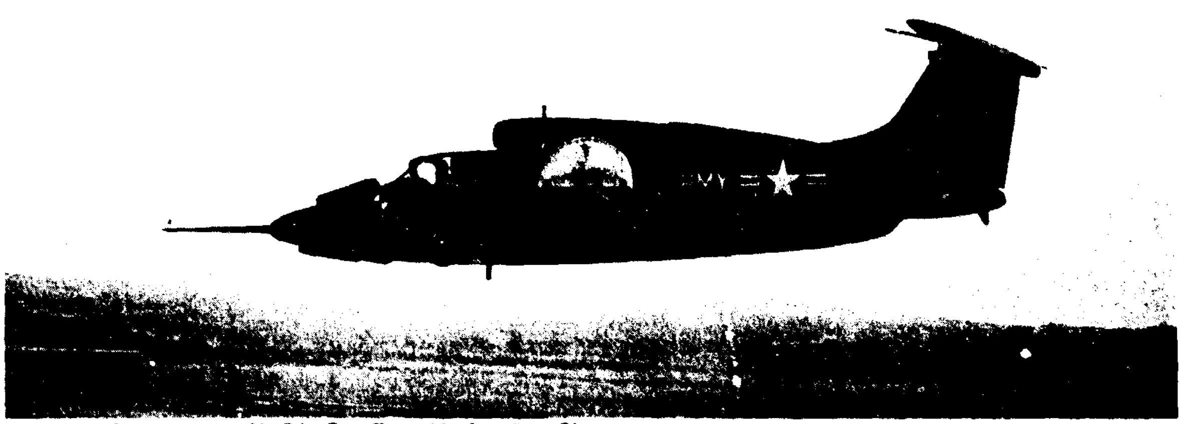


Photo 8- XV-5A In Fan-Mode Configuration at 50 knots

2.2.7.1 Objective

The objective of the tests was to determine the airspeed position error of the nose-boom (low-airspeed) system during fan flight.

2.2.7.2 Method

The airspeed calibration of the low-airspeed system was accomplished by flying formation with a calibrated pace helicopter. The aircraft was calibrated over an approximate indicated airspeed range of 30 to 85 knots, at angles of attack of -2, zero and +5 degrees. These tests were conducted out of ground effect at an average altitude of 5800 feet.

2.2.7.3 Results

Test results are presented graphically in Figure 86, Appendix I.

2.2.7.4 Quantitative Engineering Analysis

The nose-boom (low-airspeed) system indicated low for all airspeeds between 30 and 85 KIAS. The position error was linear with a value of 3 knots. This position error was constant for an angle of attack range of -2 to +5 degrees.

The wing-boom (high-airspeed) system was not reliable at airspeeds below 80 KIAS. This system, therefore, was not calibrated for FM flight.

Additional testing is required to determine the effect of climbs and descents on the position error.

2.3 JET-MODE STABILITY AND CONTROL

2.3.1 JET-MODE LONGITUDINAL TRIM CHANGES

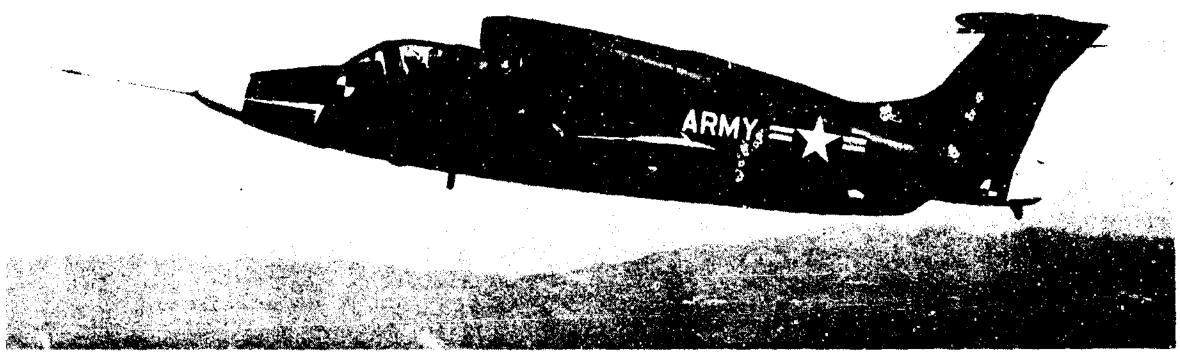
2.3.1.1 Objective

The objective of these tests was to investigate the longitudinal trim characteristics resulting from various inflight configuration changes.

2.3.1.2 Method

The longitudinal trim changes were evaluated by first trimming the test aircraft in a selected flight condition and configuration. This configuration was then changed and the control movements

Photo 9- XV-5A In Jet-Mode



required for the trim change were recorded. These changes included gear position, flap setting, power condition and pre-conversion configuration. Data were recorded at the stabilized trim condition and during the transitory motion resulting from the configuration change.

2.3.1.3 Results

Test results are presented in Table 2, Section 2.

2.3.1.4 Quantitative Engineering Analysis

The magnitude and rate of trim change were easily trimmed by use of the horizontal stabilizer. No measurable lateral or directional coupling was encountered during any of the longitudinal trim change tests. The findings of the longitudinal trim change tests are summarized in Table 2.

Many of the longitudinal trim change tests could not be conducted because the required power setting resulted in heating in the right wing-fan area. This characteristic was unsatisfactory and should be corrected. Recommendation 1.7.1f

2.3.1.5 Qualitative Pilot Comments

As shown in Table 2, all configuration changes concerned with flap retraction or flap extension resulted in longitudinal control stick forces in excess of 10 pounds. The longitudinal forces encountered were easily trimmed off by repositioning of the horizontal stabilizer, which had a trim rate of .4 deg/second. The longitudinal stick forces observed during these tests, although not objectionable due to the retrim characteristics, exceeded the maximum allowable forces specified in Paragraph 3.3.19 of MIL-F-8785 (ASG). A pilot opinion rating of 3 was assigned to the observed longitudinal trim change characteristics of the XV-5A.

[illegible] LONGITUDINAL TRIM [illegible]

[illegible]					Test		[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	Power	Change	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	0	Conv Up	PFLP	Gear Down	Altitude	[illegible]	[illegible]
[illegible]	[illegible]	0	Conv Up	PFLF	Flap [illegible] 100%	Altitude	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	Conv Up	PFLF	Idle Power	Airspeed	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	Conv Up	PFLF	Pre-conversion Configuration	Altitude	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	PFLF	Cruise Configuration	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	0	Conv [illegible]	PFLF	Flap Down 100%	Altitude	18 lb [illegible]	-5
[illegible]	[illegible]	[illegible]	Conv Up	PFLF	Louver to Fan	Altitude	4 lb [illegible]	-5

* Maximum stick force required to accomplish test.

** Horizontal stabilizer position required to re-trim aircraft after configuration change (maximum trim available was -5 degrees, aircraft nose up).

2.3.2 JET-MODE STATIC LONGITUDINAL STABILITY

2.3.2.1 Objective

The objective of these tests was to evaluate the static trim stability, the static longitudinal stability, and the horizontal stabilizer trim effectiveness.

2.3.2.2 Method

The static trim stability was investigated by stabilizing at the desired airspeed and then trimming the aircraft for zero forces. At this trimmed condition, the attitude, angle of attack, stabilizer position and control positions were recorded.

The static longitudinal stability was evaluated by stabilizing and trimming the aircraft for hands-off flight. Then with engine power and trim controls fixed, airspeed was varied through a specified range by use of the longitudinal stick. At each stabilized point about the trim airspeed, the control force, control position, angle of attack and attitude were recorded.

The horizontal stabilizer trim effectiveness was investigated by stabilizing and trimming the aircraft at the desired trim airspeed. Then a constant airspeed was maintained, and the horizontal stabilizer was changed to various out-of-trim positions. At each of these conditions, the stick force, stick position, angle of attack and pitch attitude were recorded.

2.3.2.3 Results

Test results are presented graphically in Figures 87 through 94, Appendix I.

2.3.2.4 Quantitative Engineering Analysis

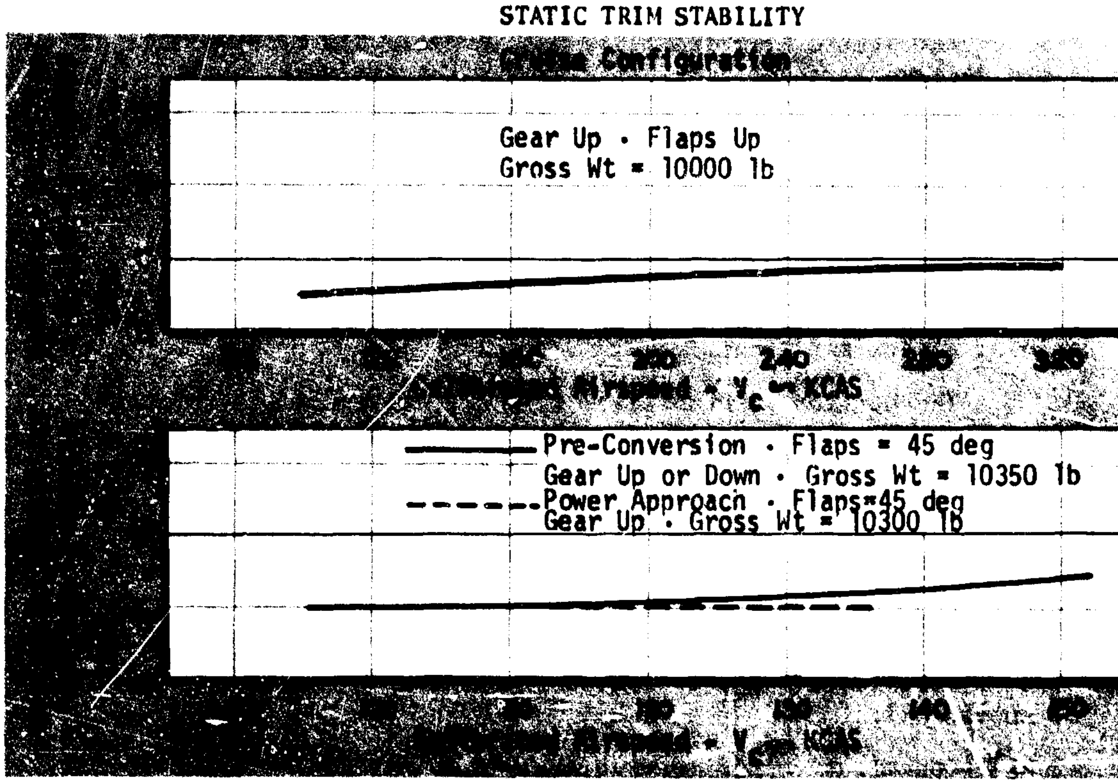
2.3.2.4.1 Static Longitudinal Trim Stability

For cruise (CR) configuration, the static longitudinal trim stability was positive for an airspeed range of 102 to 330 KCAS and sufficient trim was available to maintain zero stick forces. For this airspeed range, the horizontal stabilizer position varied from 2.7 to .5 degrees leading edge down. The trim stability was neutral for the full-flaps configuration. At an airspeed of 120 KCAS, an additional 2.5 degrees of leading-edge-down horizontal stabilizer trim was required for the flaps-down conditions. The trim angle of attack was reduced approximately 6 degrees by the flap extension. Recommendation 1.7.2 f

Longitudinal trim stability was positive at airspeeds above 105 KCAS for PC configuration. At 100 KCAS, the trim requirement was similar to that in flaps-down, gear-up configuration. The

trim required decreased rapidly with increasing airspeed and above 150 KCAS approached that required for flaps-up configuration. The data showed similar characteristics for both gear-up and gear-down PC configurations and is graphically illustrated in Figure I . Recommendation 1.7.2.f.

FIGURE I
SUMMARY OF JET MODE
STATIC TRIM STABILITY



2.3.2.4.2 Static Longitudinal Stability

The longitudinal stability, stick-fixed and stick-free, was positive with aft stick displacement and pull stick force required to decrease airspeed. At airspeeds below 140 KCAS the longitudinal stick displacements and forces required to vary airspeed about the trim point were nonlinear. No significant lateral or directional displacements or forces were required as airspeed was varied from trim.

Stability characteristics for airspeeds below 120 KCAS are presented in Paragraph 2.3.3, Jet-Mode Stall Characteristics. The excessive structural heating encountered at high engine power (Paragraph 2.3.1.4) prevented obtaining data at airspeeds above 330 KCAS.

2.3.2.4.2.1 Stick-Fixed Longitudinal Stability

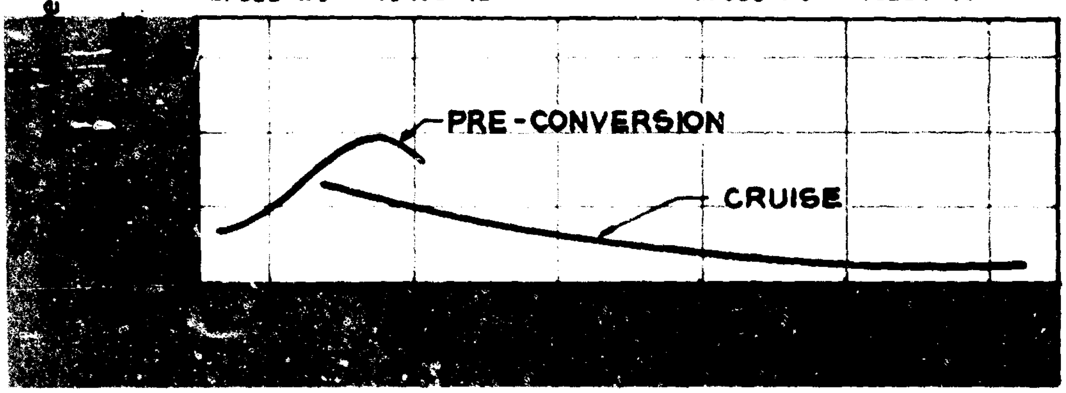
The stick-fixed longitudinal stability gradient $d\delta_{s_e}/dv$ was positive and nonlinear over the airspeed range tested in CR configuration. The stability became less positive as trim airspeed was increased above 120 KCAS. Extrapolation of the test data, however, indicated that the stick-fixed stability would remain slightly positive at all airspeeds up to the maximum airspeed limit. Lowering the flaps to the full-down position resulted in a lower stability at an airspeed of 136 KCAS.

The stick-fixed stability gradient was positive and nonlinear for PC configuration for an airspeed range of 104 to 163 KCAS. The stability increased with airspeed from 104 KCAS and reached a maximum at 150 KCAS. At 150 KCAS a reversal occurred and increased airspeed resulted in a lower stability level. The landing gear position did not significantly affect the stick-fixed stability in PC configuration. The stick-fixed stability characteristics for JM, CR and PC configurations are graphically summarized in Figure J .

FIGURE J
SUMMARY OF JET MODE STICK FIXED
STATIC LONGITUDINAL STABILITY

PRE-Conversion Configuration
Gear Up or Down
Pressure Alt = 5000 ft
Gross Wt = 10400 lb

CRUISE Configuration
Gear Up
Pressure Alt = 10000 ft
Gross Wt = 10200 lb



2.3.2.4.2.2 Stick-Free Longitudinal Stability

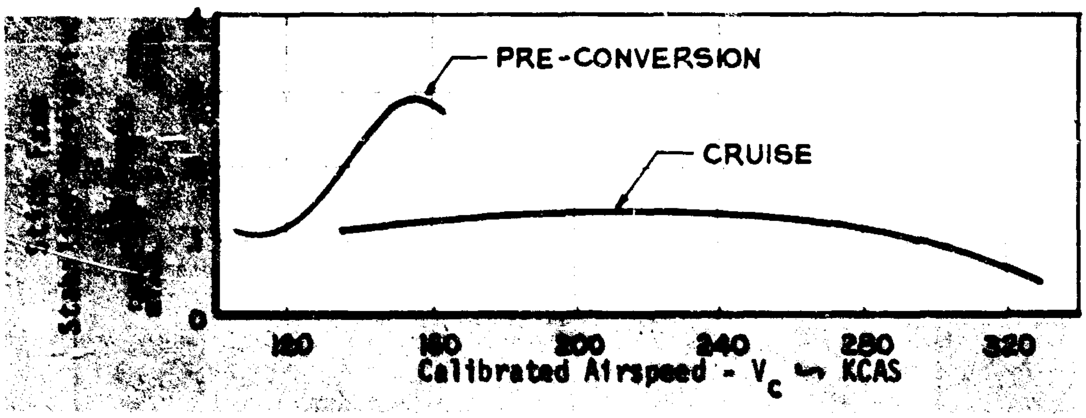
The stick-free longitudinal stability gradient dF_e/dv was positive and nonlinear over the airspeed range investigated for CR configuration. The stability gradient varied from .11 pounds/knot to .04 pounds/knot at 134 and 330 KCAS respectively. Extrapolation of test data indicated that the stick-free stability might become neutral at 345 KCAS and might be negative at higher speeds.

Lowering the flaps from up to full down had a destabilizing effect on the stick-free stability.

The stick-free longitudinal gradient for PC configuration varied from .11 pounds/knot at 105 KCAS to .25 pounds/knot at 156 KCAS. The stick-free stability characteristics were similar to the stick-fixed stability characteristics and were positive and nonlinear throughout the airspeed range. The stick-free stability characteristics for JM, CR and PC configurations are presented in Figure K.

FIGURE K
SUMMARY OF JET MODE STICK FREE
STATIC LONGITUDINAL STABILITY

PRE-Conversion Configuration	CRUISE Configuration
Gear Up or Down	Gear Up
Pressure Alt = 5000 ft	Pressure Alt = 10000 ft
Gross Wt = 10400 lb	Gross Wt = 10200 lb



2.3.2.4.3 Horizontal Stabilizer Trim Effectiveness

The horizontal stabilizer trim effectiveness tests demonstrated sufficient authority to trim the aircraft for any change in pitching moment with configuration change. The trimmable stabilizer had the capability of providing nose-down pitching moments which could not be overcome with the elevator power available. Longitudinal stick required with stabilizer position change was linear and the maximum value of .68 in/deg occurred at a trim airspeed of 155 KCAS. Figure 94, Appendix I, illustrates the maximum stabilizer position that can be overcome with the maximum longitudinal stick travel.

The stick-force change with stabilizer angle was non-linear with an increasing gradient as the departure from trim became greater. The force gradient increased with trim airspeed and varied from 3 pounds/degree at 105 KCAS to 8.5 pounds/degree at 155 KCAS.

2.3.2.5 Qualitative Pilot Comments

2.3.2.5.1 Static Longitudinal Stability (Pilot Opinion Rating: 3)

Shallow positive stick force gradients and large trim bands about the trim airspeeds described the typical static longitudinal stability characteristics in PC and CR configurations. These characteristics, more pronounced in PC configuration, were not objectionable and provided satisfactory speed control for "smooth air" test conditions. Any further XV-5A testing should include similar tests conducted under turbulent flight conditions. The reversible longitudinal control system was not objectionable for airspeeds below 250 KIAS. During flights conducted at airspeeds above 250 KIAS, the longitudinal control stiffness was disconcerting. A pilot opinion rating of 3 was assigned to the jet-mode static longitudinal stability characteristics. Recommendation 1.7.3f

2.3.2.5.2 Longitudinal Trimmability (Pilot Opinion Rating: 4)

The horizontal stabilizer was an extremely effective longitudinal trim control. At 140 KIAS in PC configuration a 4-degree "off-trim" horizontal stabilizer position resulted in a 30-pound control stick force to maintain level flight. To provide for a "runaway trim" situation, the pilot was alerted of horizontal stabilizer movement, either requested or unrequested, by cockpit visual and aural signals. During this evaluation two horizontal stabilizer trim rates were investigated. The .2-deg/second trim rate was too slow at airspeeds less than 150 KIAS and .4-deg/second trim rate was too fast at airspeeds above 250 KIAS. To eliminate this shortcoming, a variable trim rate device should be incorporated in the longitudinal control system. A pilot opinion rating of 4 was assigned to the jet-mode longitudinal trimmability characteristics. Recommendation 1.7.2f

2.3.3 JET-MODE STATIC LATERAL-DIRECTIONAL STABILITY AND EFFECTIVE DIHEDRAL

2.3.3.1 Objective

The objective of the static lateral-directional stability tests was to determine the static-directional stability and the effective dihedral throughout the jet-mode flight envelope.

2.3.3.2 Method

The static lateral-directional stability and effective dihedral were evaluated by recording the control forces, control displacements and resulting bank angle required to produce a given sideslip angle. The aircraft was stabilized at the desired airspeed and at various constant-heading sideslips. At each stabilized point data was recorded.

Static directional stability was determined from the relationship between pedal position and angle of sideslip. Effective dihedral was determined from lateral control variation with sideslip angle.

2.3.3.3 Results

Test results are presented graphically in Figures 95 through 104, Appendix I.

2.3.3.4 Quantitative Engineering Analysis

2.3.3.4.1 Static Directional Stability

The static directional stability characteristics were positive (right pedal required for left sideslip) for all conditions tested. The pedal displacement required as sideslip was varied about the trim point was symmetrical and generally linear.

2.3.3.4.1.1 Pedal-Fixed Static Directional Stability

The pedal-fixed directional stability gradient was positive for all conditions tested in CR configuration. This stability gradient became more positive and was slightly nonlinear as airspeed was increased from 133 KCAS to 325 KCAS. At 325 KCAS, extrapolation of the test date shows a maximum sideslip angle of approximately 5 degrees for full-pedal deflection. At 150 KCAS the static directional stability was unchanged by a full-flap extension.

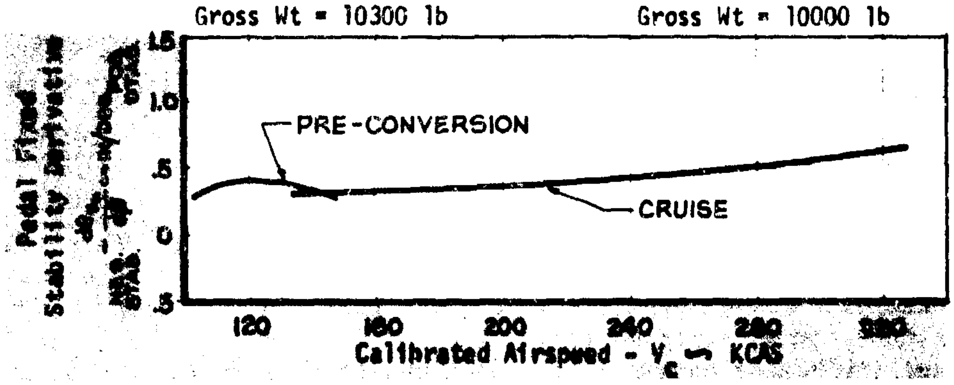
The pedal-fixed stability was positive for PC configuration. The stability was nonlinear with airspeed and the maximum positive stability gradient occurred at 122 KCAS. The stability gradient then decreased with airspeed but remained positive for airspeeds up to the maximum PC speed limit. No change in the stability gradient with the gear position was noted. The pedal-fixed stability characteristics are presented in Figure L .

2.3.3.4.1.2 Pedal-Free Static Directional Stability

The pedal-free static directional stability gradient

FIGURE L
SUMMARY OF JET MODE PEDAL FIXED
STATIC DIRECTIONAL STABILITY

PRE-Conversion Configuration	CRUISE Configuration
Gear Up or Down	Gear Up
Pressure Alt = 5200 ft	Pressure Alt = 9500 ft
Gross Wt = 10300 lb	Gross Wt = 10000 lb

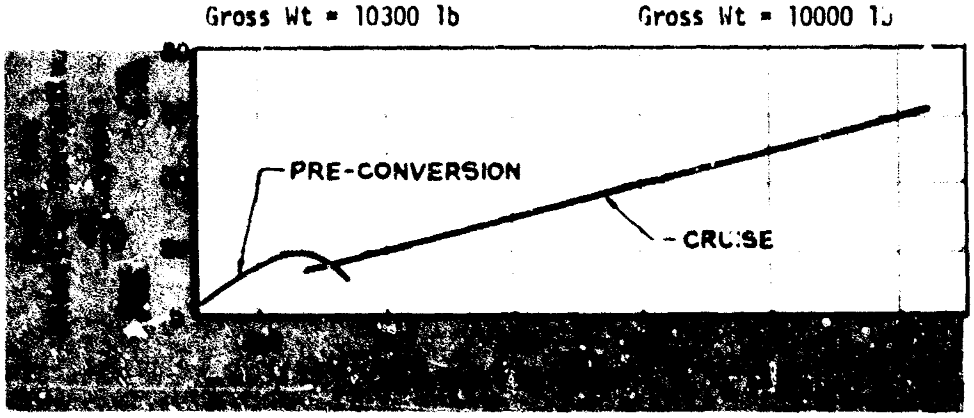


dF_r/dB was positive and linear for CR configuration. The gradient increased rapidly with airspeed and varied from 12 pounds/degree at 133 KCAS to 60 pounds/degree at a speed of 325 KCAS.

In pre-conversion the pedal-free stability was positive at all speeds. The stability gradient varied in a nonlinear manner from 3.0 pounds/degree at 102 KCAS to 18 pounds/degree at 135 KCAS. A further increase in airspeed resulted in a slight decrease in the gradient. The stability was not significantly influenced by the gear position. The pedal-free static directional stability for jet-mode is graphically presented in Figure M.

FIGURE M
SUMMARY OF JET MODE PEDAL FREE
STATIC DIRECTIONAL STABILITY

PRE-Conversion Configuration	CRUISE Configuration
Gear Up or Down	Gear Up
Pressure Alt = 5200 ft	Pressure Alt = 9500 ft
Gross Wt = 10300 lb	Gross Wt = 10000 lb



2.3.3.4.2 Effective Dihedral

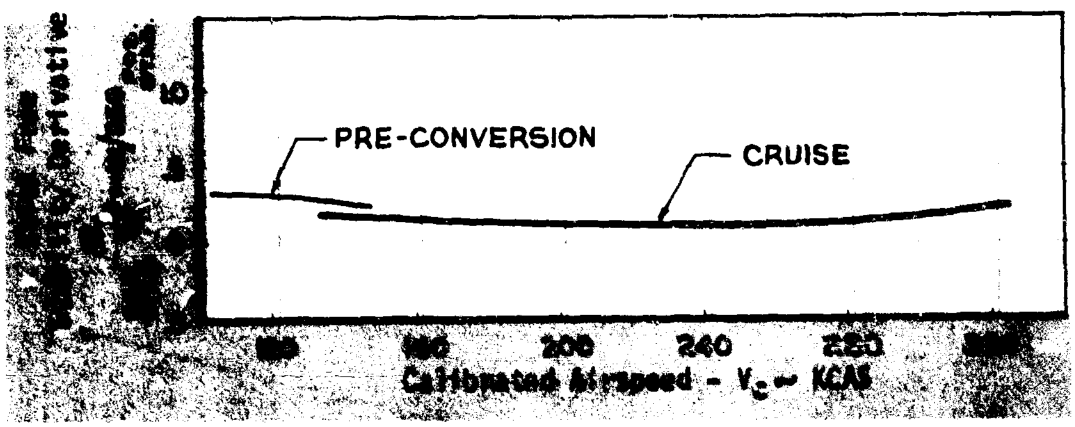
The effective dihedral was generally positive with increasing lateral stick displacement and force required to increase the constant-heading sideslip angle. The lateral control and force requirements were linear as sideslip angle was varied from trim. A degradation in the stick-free characteristics resulted from the flaps being lowered to 100 percent.

2.3.3.4.2.1 Stick-Fixed Effective Dihedral

The stick-fixed dihedral effect gradient $d\delta s_a/d\beta$ was positive and nonlinear for all conditions tested. The magnitude of the stick-fixed gradient in CR configuration was essentially constant for an airspeed range from 133 KCAS to 325 KCAS. The stability became more positive when the flaps were lowered to 100 percent. This increase in stability may have been influenced by the 15 degrees of aileron droop with flap extension. The stick-fixed effective dihedral stability is graphically summarized in Figure N.

FIGURE N
SUMMARY OF JET MODE STICK FIXED
EFFECTIVE DIHEDRAL

PRE-Conversion Configuration	CRUISE Configuration
Gear Up or Down	Gear Up
Pressure Alt = 5200 ft	Pressure Alt = 9500 ft
Gross Wt = 10300 lb	Gross Wt = 10000 lb



2.3.3.4.2.2 Stick-Free Effective Dihedral

The stick-free dihedral effect gradient dF_a/dB was slightly positive to neutral for CR configuration. The magnitude

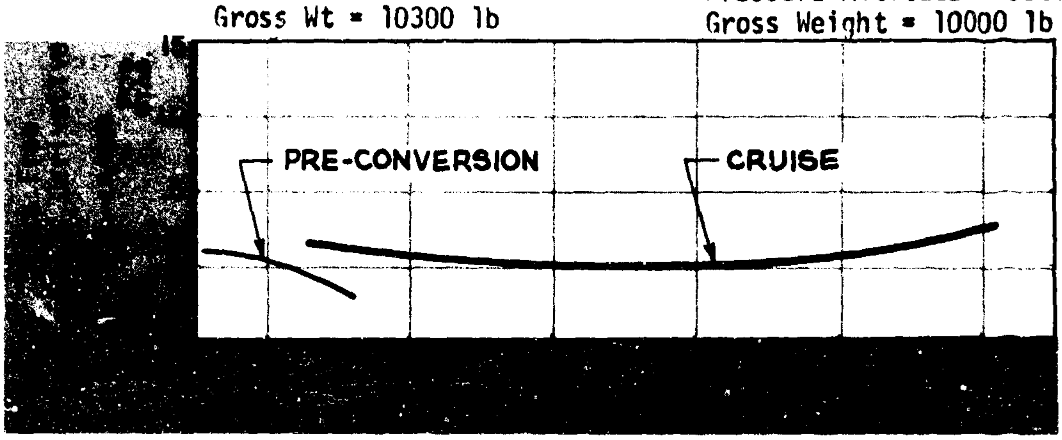
of the stick-free gradient varied from .15 pounds/degree at 133 KCAS to neutral at 220 KCAS. The stability then increased gradually to a value of .3 pounds/degree at 325 KCAS. The stability was negative with flaps down at an airspeed of 150 KCAS.

In PC mode the stick-free stability was a positive 0.1 pounds/degree at 102 KCAS. The stability then decreased with increased airspeed and became neutral at 124 KCAS. The stability was negative at speeds higher than 144 KCAS.

The stick-free effective dihedral characteristics for jet-mode are summarized in Figure O.

FIGURE O
SUMMARY OF JET MODE STICK FREE
EFFECTIVE DIHEDRAL

PRE-Conversion Configuration	CRUISE Configuration
Gear Up or Down	Gear Up
Pressure Alt = 5200 ft	Pressure Altitude = 9500 ft
Gross Wt = 10300 lb	Gross Weight = 10000 lb



2.3.3.4.3 Longitudinal Coupling

A limited amount of longitudinal coupling was encountered during the static lateral-directional tests. This longitudinal coupling required increasing aft force and control displacement as sideslip was increased in either direction. The force and control displacement requirement was linear. The maximum longitudinal pull force required at 50 pounds pedal force was 7 pounds at 133 KCAS and 1.0 pound at 325 KCAS.

2.3.3.5 Qualitative Pilot Comments (Pilot Opinion Rating: 3)

In PC and CR configurations positive directional stability and positive dihedral effect were observed during steady-heading

sideslips. Typical results of this portion of the evaluation are shown in Figures 95 through 100, Appendix I. No undesirable flight characteristics were observed during this portion of the lateral-directional investigation. The apparent lack of harmony between lateral and directional control forces evidenced by the data shown in Figures 101 and 104 was not objectionable to the pilot. There did exist a nuisance tendency for the aircraft to wander in yaw (± 2 degrees maximum) in PC configuration at airspeeds below approximately 110 KIAS. Above 110 KIAS the aircraft's "directional stiffness" increased with airspeed in both PC and CR configurations as evidenced by the 325 KCAS data in Figure 99. These results enhanced the lateral-directional flying qualities of the XV-5A. In PC configuration at 140 KIAS the aircraft tended to oscillate laterally after a wind gust disturbance. This oscillation was damped with airspeed reduction. It is recommended that the full-flap extension limit speed (see Page 1 of Appendix IV) be reduced from the present limit speed of 180 KIAS to a limit speed of 140 KIAS. No investigation of lateral control effectiveness was conducted during this evaluation. Qualitative results indicated that maximum roll rates in CR configuration would be pilot-limited rather than control-power-limited. The XV-5A appeared to have higher maximum roll rates than the previously evaluated Navy A4B, which developed roll rates in CR configuration at 250 KIAS in excess of 250 deg/second. A pilot opinion rating of 3 was assigned to the JM lateral-directional stability characteristics observed during this evaluation. Recommendation 1.7.2 g

2.3.4 JET-MODE STALL CHARACTERISTICS

2.3.4.1 Objective

The objectives of the stall tests were to evaluate the characteristics of the aircraft in the unaccelerated and accelerated stall and to determine the minimum safe airspeeds.

2.3.4.2 Method

The aircraft was first trimmed at the specified airspeed and configuration. For the unaccelerated stall test, the airspeed was then reduced at a rate of approximately 1 knot/second until the aerodynamic stall or minimum flying speed was reached. All pertinent data parameters were continuously recorded from the trim conditions through the stall recovery.

All tests were conducted at an average gross weight of 11,000 pounds and a pressure altitude of 14,000 feet. The longitudinal C.G. varied from Station 240.2 to Station 242.9.

2.3.4.3 Test Results

The unaccelerated stall test results are presented graphically in Figures 105 through 110, Appendix I. Accelerated stall tests were not conducted.

2.3.4.4 Quantitative Engineering Analysis

In all tests an aerodynamic stall was reached before a minimum control speed occurred.

The stick-fixed stability during approach to stall was neutral to slightly negative. The highest instability recorded was 0.2 inches of forward longitudinal stick input required per knot of airspeed decrease.

The stick-free stability varied from slightly positive for the 25-percent flaps, gear-down, power-approach (PA) configuration to neutral or negative for all other test configurations. The most negative stability was 2.2 pounds of push force for each knot decrease in airspeed for the full-flaps, gear-down, PA configuration. No flap-up stalls were accomplished.

Stability, both stick-fixed and stick-free, was linear from the trim condition down to the actual stall. At the stall, the longitudinal control forces decreased, the aircraft pitched down, then rolled approximately 30 to 40 degrees. The roll was usually to the left but in some cases was to the right. A yawing oscillation accompanied the roll and pitch at the stall.

Stall tests were terminated by the stall illustrated in Figures 109 and 110, Appendix I. On this stall the gear was up and center of gravity (C.G.) was the most aft of all the test conditions. The stall approach was normal; however, after the stall, the recovery was similar to the recoveries of previous stalls. The aircraft stayed in the stalled condition with random motions about all axes. Control inputs were accomplished but apparently did not result in a recovery. Approximately 7000 feet of altitude were lost during the stall maneuver and then an unexplained recovery occurred.

Lateral and directional controls were highly positive during the approach and at the stall. Recommendation 1.7.3h

2.3.4.5 Qualitative Pilot Evaluation

The following discussion is based upon the results of the

contractor-conducted flight to investigate JM stall characteristics. The results of this investigation were as follows:

Configuration	Gross Weight/CG (lb/Station)	Angle of Attack at Buffet Onset	Stall (KIAS/ α i)	Recovery
PA	11,300/243.8	20°	90/23.5°	Immediate
PA	11,250/243.8	20°	90/23°	"
PC (LG Down)	11,200/243.8	20°	80/23°	"
PC (LG Up)	11,150/243.8	20°	80/23°	Post Stall Gyration*

*Aircraft developed large sink rate with a slow pitch-up to a nose-high position. Pilot reported a lateral oscillation in the nose-high position with no response to primary controls. Stall was recovered after a loss of approximately 7000 feet after lateral oscillation to the right caused nose to fall through. Engine power was at or above 92 percent throughout the post-stall gyration.

These limited results indicated that the XV-5A's power-on stall characteristics included the undesirable post-stall gyration. Any future investigation should include the determination of the effectiveness of power reduction as a power-on stall recovery technique. Recommendation 1.7.3h

2.3.5 JET-MODE ASYMMETRIC POWER

2.3.5.1 Objective

The objectives of these tests were to determine the control displacements and forces required to maintain zero sideslip and to determine the minimum single-engine control airspeed.

2.3.5.2 Method

The aircraft was trimmed at 1.4 V_{stall} with both engines operating at 98-percent power. The airspeed was then increased to 1.8 V_{stall} and one engine was returned to idle. The aircraft was stabilized at zero sideslip and the airspeed was reduced until the stall speed was approached. The resulting transient and steady-state control displacements and forces requirements were recorded. A positive rate of climb was maintained at all times during the tests. The rate of climb varied from 1500 to 500 feet/minute.

2.3.5.3 Results

Test results are presented in Paragraph 2.3.5.4.

2.3.5.4 Quantitative Engineering Analysis

Adequate lateral and directional controls were available at airspeed above the minimum tested (120 KCAS) with the gear up and a flap setting of 25 percent. The minimum control airspeed in this configuration was not established. The resulting change in directional control position and force to maintain zero sideslip was found to be .3 inches left and 20 pounds left as airspeed was varied from 160 to 120 KCAS. The change in lateral control and force requirement was found to be negligible.

2.3.5.5 Qualitative Pilot Comments (Pilot Opinion Rating: 2)

No objectionable flying qualities were encountered during the tests. A pilot opinion rating of 2 was assigned to the conventional asymmetric power flying qualities observed during these tests.

2.3.6 JET-MODE DYNAMIC STABILITY

2.3.6.1 Objective

The objective of these tests was to evaluate the dynamic stability characteristics of the XV-5A aircraft.

2.3.6.2 Method

The JM short-period dynamic stability was evaluated by first trimming the aircraft to the prescribed flight conditions, then introducing a disturbance by means of rapid pulse-type control input. The resulting oscillations were then allowed to continue until the motion was damped out or recovery was necessary. The tests were conducted both stick fixed and stick free.

2.3.6.3 Results

Time histories are presented graphically in Figures 111 through 118, Appendix I.

2.3.6.4 Quantitative Engineering Analysis

The short-period dynamic longitudinal stability was positive and heavily damped in CR configuration. All rates and accelerations were in the proper direction and were essentially damped to zero in 1 cycle. No residual oscillations occurred. Angle of attack and

airspeed returned very nearly to the trim conditions. The charac-teristics were essentially the same for all airspeeds from 135 to 256 KCAS. The stability characteristics for the PA configuration were the same as those encountered for the CR configuration. Quan-titative lateral-directional tests were not conducted for this con-figuration.

A lateral disturbance resulted in a lightly damped lateral oscillation and a bank angle was established in the direction of control input. Yaw rate was damped to zero within 1 cycle and a sideslip angle was established in the same direction as the bank angle. Lateral-directional damping was weakly positive at 105 KCAS. The roll oscillation was larger and opposite the yaw motion.

2.3.6.5 Qualitative Pilot Comments (Pilot Opinion Rating: 2.5, Dynamic Longitudinal Stability; 3, Lateral-Directional Stability)

Results of a limited dynamic longitudinal stability inves-tigation in conventional flight (PC and CR configurations) showed the longitudinal damping to be heavy in both configurations tested. At 250 KIAS in CR configuration, the short-period mode was deadbeat. A near deadbeat short-period modewas observed during any portion of this phase of the evaluation. A pilot opinion rating of 2.5 was assigned to the jet-mode dynamic longitudinal stability character-istics and a rating of 3 to the lateral-directional characteristics.

2.3.7 JET-MODE AIRSPEED CALIBRATION

2.3.7.1 Objective

The objective of this test was to determine the position error of both the wing-boom (high-airspeed) system and the nose-boom (low-airspeed) system.

2.3.7.2 Method

The airspeed calibration of the low-airspeed system (less than 150 knots) and the high-airspeed system was accomplished by flying formation with a calibrated pace aircraft. Both systems wore calibrated in clean, PA and PC configurations. The tests were con-ducted out of ground effect at an altitude ranging from 5000 to 15,000 feet at an average gross weight of 10,500 pounds.

2.3.7.3 Results

Test results are presented graphically in Figure 119, and 120, Appendix I.

2.3.7.4 Quantitative Engineering Analysis

The nose-boom (low-airspeed) system position error was nonlinear for all configurations and varied in magnitude from a minimum of -4.5 knots to a maximum of +9.0 knots. For CR configuration, the position error varied from a value of -4.5 knots at 103 KIAS to +4.5 knots at 135 KIAS. In PC configuration with gear up or down, the position error varied from -3 knots at 95 KIAS to +9 knots at 143 KIAS. The position error in PA configuration was positive and had a value of +3 knots at 103 KIAS and varied to +8.5 knots at 123 KIAS.

The wing-boom (high-airspeed) system position error was nonlinear and was the same for all configurations. The position error varied from -7.3 knots at 110 KIAS to +.3 knots at 175 KIAS. The position error then decreased from +.3 knots at 175 KIAS to -1.5 knots at 230 KIAS and remained essentially the same up to an airspeed of 293 KIAS.

2.4 TRANSITION STABILITY AND CONTROL Photo 10

2.4.1 HOVERING AND VTOL FLIGHT

2.4.1.1 Objective

The objective of these tests were to evaluate the control requirements, stability, and pilot effort during vertical lift-offs, vertical climbs and descents, hovering and vertical landings.

2.4.1.2 Method

The vertical maximum performance lift-offs were initiated by applying maximum engine power and full-down collective. After obtaining maximum engine power, the collective (lift) control was raised from the full-down position to the full-up position. The aircraft then lifted off the ground and a vertical climb was performed to an altitude of approximately 500 to 800 feet. The necessary control inputs were applied to maintain a constant-heading level-aircraft attitude during the lift-off and climb. At this altitude the rate of climb was decreased by lowering the collective control. Aircraft altitudes, rates, flight control positions, etc. were recorded during each vertical climb.

The maximum-engine-power vertical descents were performed by descending from a stabilized hover at an altitude of 500 to 800 feet. The rate of descent was controlled by the collective control. A constant-heading level-aircraft attitude was maintained during the descent by applying the necessary control inputs. The descent was terminated by increasing the collective to achieve a stabilized hover condition. Data were recorded during each vertical descent.

Data were recorded while hovering at various wheel heights with the aircraft engines developing maximum power. The collective control was used to maintain the desired wheel height. Control inputs were applied during the hover so a level attitude and constant heading could be maintained.

Vertical landings were performed by using the collective control. The engine power and collective were adjusted so a continuous descent and landing could be performed without adjusting power. After the main landing gear touched the ground, the collective was lowered to the full-down position and engine power was reduced.

2.4.1.3 Test Results

The results are summarized graphically in Figures 121 through 126, Appendix I.

2.4.1.4 Quantitative Engineering Analysis (SAS On)

2.4.1.4.1 Fan-Mode Vertical Takeoff and Climb

Maximum vertical takeoff was accomplished by setting engine power at the maximum and increasing the collective control from down to full-up in 0.6 seconds. This provided maximum takeoff performance and reduced the time spent in the turbulent air-flow pattern encountered close to the ground. Approximately 1 inch of aft stick was used to clear the nosewheel and reduce reingestion prior to applying the collective control. This aft stick input resulted in a pitch attitude change of +12 degrees. As power was increased, a yawing tendency that required pedal inputs of ±.5 inches was noted. As the collective control was increased a small roll oscillation of 2 cycles duration occurred. As the aircraft was lifted off with collective control, the longitudinal stick was moved forward approximately 2 inches. This was sufficient to decrease the pitch attitude to essentially level. No large aircraft motions or attitude changes resulted from the rapid collective control input.

During the stabilized vertical climb small-amplitude random motions occurred about all axes. No apparent adverse stability characteristics resulted from the increased vertical drag or from any fan thrust changes caused by induced flow variations. Control motions were relatively small, the largest being ±.7 inches of lateral input.

The rate of climb was checked by decreasing the collective control. No significant aircraft motions or control requirements resulted from this maneuver.

2.4.1.4.2 Fan-Mode Vertical Descent

During the vertical descent very small random pitch and roll rates were experienced. Stick requirements were frequent but of very small magnitude. There were no significant attitude changes. The directional stability was apparently very weak or neutral. The aircraft tended to yaw indiscriminately and required pedal input to return to the initial heading.

2.4.1.4.3 Hovering at a Wheel Height of 50 Feet

The control inputs required to maintain a stabilized hover at this wheel height were relatively small. The longitudinal and lateral stick varied ±.3 inches about the trim position and the pedal variation was ±.2 inches. All the control requirements were gradual and random. The control was positive in all axes and

no apparent negative stability existed.

The SAS inputs effectively damped the rates and generally were in the same direction as the stick inputs. The results were a very stable hover condition with attitude changes on the order of 1 degree. Essentially no collective control inputs were required to maintain constant hover height.

2.4.1.4.4 Hovering at Wheel Heights Below 6 Feet

At a wheel height of 5 feet the control requirements were considerably greater than at 50 feet. Continual longitudinal and lateral control inputs were required. The rates about all axes were apparently random. The frequency and/or occurrence of the rates and the pilot input and SAS input made it difficult to ascertain cause and effect. In some cases, the pilot input opposed the SAS action. The control inputs required to maintain a hover may have contributed to the many small rate variations. The hover attitude could be held fixed. Collective control variations of ± 10 percent were required to maintain the trim wheel height. This control motion appeared to be an oscillation with a period of approximately 3 seconds.

As the wheel height was decreased to 3 feet, the effect of the turbulent air flow became more apparent. This turbulence increased the magnitude and frequency of the aircraft disturbances. The overall stability was generally decreased while the controllability remained immediate and positive at all times. Rapid and random control inputs were required more frequently and were of greater magnitude. Lateral control requirements were the greatest with a maximum of 2 inches of stick being used. Pedal inputs were 1 inch and the longitudinal stick required was 0.5 inches. The SAS inputs had a maximum of 75 percent of full authority and,in some cases, were opposite the pilot input. The aircraft motion could not be correlated with the SAS and control inputs. The aircraft hover attitude was held fixed about all axes with no significant deviations.

Thrust changes were random and quite large, and 50-percent collective stick variations were used to maintain the hover height.

2.4.1.4.5 Hover Landing

At low wheel heights just prior to and during touch-down, large and rapid stick motions were required to maintain attitude. Immediately after the main gear contacted the ground, a lateral rate oscillation occurred. This oscillation was sensed

by the SAS and the corresponding control inputs occurred. As the collective was lowered large rapid oscillatory SAS motions in pitch also occurred. There were some yawing tendencies which required ± 1-inch pedal inputs. As the collective reached the full-down position the increased weight on the gear damped the lateral motion. While the engine power was reduced the longitudinal stick was moved aft to hold the nose gear off the ground. The landing was then completed by moving the longitudinal stick forward approximately 1.5 inches; this reduced the pitch-fan pitching moment and allowed the nose gear to contact the ground. This contact induced some longitudinal SAS action which damped as the weight on the gear increased.

2.4.1.5 Qualitative Pilot Comments (Pilot Opinion Rating: 5.5, VTOL to 10-Foot Wheel Heights; 3, Vertical Climb to 1000 Feet; 3.5, Hover Above 10-Foot Wheel Height; 3.5, Hover Translation Handling Qualities)

The vertical takeoff and landing characteristics in close proximity to the ground (zero to 10-foot wheel heights) comprised the weakest portion of the flying qualities of the XV-5A and detracted from the aircraft's ability to accomplish its primary research mission. A pilot opinion rating of 5.5 was assigned to these characteristics.

During vertical takeoffs, immediately after the main gear lift-off, the test aircraft exhibited moderate disturbances about all axes which caused the pilot to remain in this region a minimum time. The intensity of the disturbances decreased as wheel height increased and was completely eliminated at a wheel height of approximately 10 feet. Due to the severity of the disturbances (see Figures 124, 125, and 126, Appendix I) the ability to perform precise tasks in a zero to 10-foot wheel height regime is questionable. This result dictates that all prolonged hover operations be conducted at wheel heights above 10 feet, where a single engine failure would result in aircraft damage and possible pilot injury. This problem was complicated by two other unsatisfactory aircraft characteristics which became more noticeable during vertical takeoffs: engine reingestion and degradation of available lateral control power with increased lift-stick position. The net effect of engine reingestion, fully discussed in Reference n , was to reduce total lift in l configuration. Reference n showed the intensity of engine reingestion to be a direct function of wind conditions and recommended the 5-knot wind limitation for vertical takeoff adhered to during this evaluation. From the cockpit this condition was noted by an apparent "hang-up" with little or no response to increased power application. To continue climb after

encountering reingestion during operations in winds of 5 knots or less, a satisfactory technique was to change aircraft attitude in pitch or yaw. This technique altered the air flow from the reingested pattern and thus permitted sufficient power to conduct a vertical climb. The second unsatisfactory characteristic was the inherent coupling of available lateral control power with lift-stick position. With a full-up lift stick a severe degradation of control from that available with a mid lift-stick position was noted. Although not encountered during this evaluation due to the 5-knot wind test limitation, it is easy to forsee the potential results of the combined effects of the three characteristics mentioned: with a lateral disturbance immediately at lift-off causing a low wing attitude and engine reingestion causing the pilot to apply full lift stick to maintain climb, the combined reingestion and lateral control demand effects would reduce available lift to a lift-to-weight ratio below 1 and the aircraft would settle to the ground in a wing-low attitude. Correction of each of the three unsatisfactory characteristics discussed is mandatory for follow-on XV-5 aircraft. Recommendation 1.7.1c, d, e

No objectionable characteristics were noted during a vertical climb to 1000 feet absolute altitude at a sustained climb rate of 1500 feet per minute. The cockpit environment was similar to that of a helicopter during the same maneuver. Ground reference was easily maintained by shifting vision to the distant horizon as altitude was increased. A pilot opinion rating of 3 was assigned to the handling qualities observed during vertical climb to 1000 feet.

Precise vertical landings were limited by the aircraft disturbances encountered below a 10-foot wheel height discussed in the preceding paragraph. Prior to a vertical landing the pilot was forced to select the proposed touchdown spot at a wheel height above 10 feet, then devote all his attention to hovering the aircraft through the region of increasing disturbance to the preselected landing spot. Due to the narrow main landing gear (8.4 feet wheel to wheel) and a large aircraft side area, the possibility of a lateral "tip-over" due to a sideward translation or wing-low attitude at touchdown was always present during hover operations in wind. To reduce this risk in addition to reducing the engine reingestion effects, hower operations were restricted to a maximum of 5 knots during this evaluation. Restricted downward visibility and landing gear location prevented the pilot from obtaining precise wheel height information in close proximity to the ground. This characteristic caused the inexperienced pilot to "hunt" for the ground and often resulted in an undesirable "bouncy" landing due to the reluctance of the pilot to reduce power until a "wheels-on-the-ground" condition was certain. Repositioning of the main landing

gear to provide a wider ground track is considered to be a mandatory requirement for follow-on XV-5 aircraft. Recommendations 1.7.1c, e, 1.7.2j

During hover at wheel heights above 10 feet the XV-5A was heavily damped about all three axes for the test condition stability augmentation system (SAS) setting. Results of dynamic steps and pulses about the three axes showed the SAS to be a very effective system. Some lateral-directional coupling was observed; however, no objectionable coupling characteristics were experienced. These results were pleasant to the pilot and provided a "steady platform" at the stationary hover. Height control with throttle manipulation resulted in pilot-induced vertical oscillations due to the slow power response. Height control with lift-stick manipulations, although not as responsive as in a gas-turbine-powered helicopter (UH-1), was satisfactory. During hovering flight, control stick "pressure forces" resulted in immediate aircraft response in the correct direction. Control stick displacements in all cases were negligible. Control harmony was excellent and enhanced the aircraft's flying qualities. The XV-5A was extremely sensitive to crosswind; a 2 - 3-mph crosswind caused the aircraft to yaw downwind. During 15-mph sideward flight this characteristic was emphatically noted by the increasing requirement to apply "lower" rudder as airspeed increased. No objectionable aircraft attitudes were observed during either 15-mph or 10-mph rearward flight. A pilot opinion rating of 3.5 was assigned to the XV-5A hover characteristics above a 10-foot wheel height.

A limited variable SAS investigation of hover characteristics above a 10-foot wheel height was conducted. The results of these tests indicated that attitude control about the pitch and yaw axes could be satisfactorily accomplished without stability augmentation. Attitude control about the roll axis required a minimum of 50 percent of test setting gains to provide adequate roll control during hover operations. The simulated control effects resulting from a single hydraulic failure were evaluated by reducing roll and yaw SAS gains to 50 percent of test settings and pitch SAS gains to zero. In this configuration the aircraft was controllable and, although not evaluated, it was believed that emergency vertical landing could be safely performed. The results of this phase of the evaluation indicated a requirement for a roll SAS during hover operations. Recommendation 1.7.3i

A comparative evaluation of the hover translation handling qualities of the XV-5A and UH-1A helicopters was conducted over a 1.7-mile course. The XV-5A control forces to accomplish the tasks of these tests were observed to be between 3 - 10 pounds, depending upon specific maneuvers being performed. To accomplish

identical maneuver in the UH-1A, control forces of approximately 1 - 3 pounds (force trim off) were noted. Increased XV-5A pilot fatigue over that encountered in the UH-1A was the manifestation of these results. The XV-5A control response about all three axes was observed to be laggardly compared with the control response of UH-1A while accomplishing identical maneuvers. Qualitatively this characteristic tended to remove the pilot from the XV-5A "control loop," whereas the quicker UH-1A control response provided the pilot with the sensation of being an integral part of the "control loop." The XV-5A was extremely sensitive to the existing 3-knot to 5-knot wind compared with the UH-1A (flown in 5- to 7-knot wind). Height control during these tests was effortless in both the XV-5A and UH-1A. Based on the results of these tests, a pilot opinion rating of 3.5 was assigned to the hover translation handling qualities of the XV-5A.

The airframe structural heating characteristic in FM configuration, either in hover or translational flight, limited FM flight duration to 10 minutes. These results were unsatisfactory and detracted from the test aircraft's suitability to perform its primary research mission. During data acquisition flights in FM configuration, the short 10-minute flight duration was too restrictive. Correction of this characteristic is mandatory for follow-on XV-5 aircraft. Recommendation 1.7.1f

2.4.2 TAKEOFF, CLIMB, AND LANDING

2.4.2.1 Objective

The objective of these tests was to evaluate the control requirements, stability and pilot effort during JM and FM takeoffs through the use of various techniques. The stability and control characteristics were also evaluated during FM climb.

2.4.2.2 Method

The aircraft was accelerated to the desired rotation speed at which time the longitudinal control was displaced aft. This action caused the aircraft to rotate and subsequently lift off and become airborne. The rotation of the aircraft was checked by forward movement of the longitudinal control. The landing gear and flaps were retracted as the aircraft continued to accelerate to the desired climb speed. The necessary corrective control inputs were performed so a constant-heading wings-level aircraft attitude could be maintained. Data were recorded during each takeoff.

The FM takeoffs were performed by using two technqiues. These techniques were:

a. Level Flight Acceleration from a 30-Foot Hover

The level-flight-acceleration technique was commenced from a hover condition at an altitude of 30 feet. The maximum engine power was used during the acceleration and climbout. The landing gear was retracted while hovering at a wheel height of 30 feet; then the aircraft was accelerated by vectoring the wing louvers aft. The collective control was raised to the full-up position as airspeed was increased. Upon reaching the desired climbout speed the aircraft was placed in a climb attitude.

b. Ground-Run Acceleration

The ground-run acceleration technique was started with the aircraft in fan mode, the collective full down and the vector angle at the maximum aft position (45 degrees). The engine power was then increased to maximum and the aircraft was accelerated on the ground. The vector angle was decreased as the desired lift-off speed was approached. The aircraft was lifted off by use of the longitudinal and collective control. The rotation was checked as the aircraft became airborne. The aircraft then climbed out at the desired airspeed.

A constant-heading wings-level attitude was maintained during each takeoff by the necessary control inputs. Data were recorded during each takeoff.

FM climbs were performed with the engines developing maximum power and collective full up. The desired climb attitude was controlled by the vector angle position and the climb airspeed was maintained by displacing the longitudinal control. A wings-level constant-heading climb was maintained by control inputs. Pertinent data parameters were recorded during each FM climb.

2.4.2.3 Test Results

The results are summarized graphically in Figures 127 through 132 , Appendix I.

2.2.2.4 Quantitative Engineering Analysis

2.4.2.4.1 Jet-Mode Takeoff and Climb

The control requirements during a conventional takeoff and climb were small. Above 70 KCAS the vertical stabilizer effectiveness was sufficient to damp all oscillations. Aft stick was applied at 70 KCAS and elevator effectiveness was apparent at 80 KCAS. A total of approximately 2.5 inches of aft stick was used during the rotation which was accomplished at 95 KCAS. The rotation was checked with 2 inches of forward stick. Immediately

after the lift-off there was a lateral trim change which required 1 inch of lateral stick. At 130 KCAS the horizontal stabilizer trim was used. As the desired climb speed was reached, additional aft stick was used to maintain climb speed. No significant aircraft motions or stick movements were required during the climb.

2.4.2.4.2 Fan-Mode Rolling Takeoff

The maximum acceleration was obtained by using the 45-degree vector angle during the initial portion of the takeoff roll. As the airspeed increased, forward stick was required to control the increasing pitch-fan pitching moment and keep the nosewheel on the ground. No significant lateral or directional control was required prior to rotation. Prior to reaching the climbout airspeed, the beta vector louvers were moved forward; then aft longitudinal stick was applied to accomplish the rotation. Moving the vector forward increased the fan lift and the aircraft became airborne when the sufficient vertical thrust was available. At this time roll and yaw rate oscillations were evident as lift stick was increased toward the full-up position. These were more pronounced at lower lift-off airspeeds. At a lift-off airspeed of 45 KCAS, the yaw rates caused an oscillatory pedal input of ±1.5 inches with a period of 2 seconds. A higher frequency, lower-amplitude lateral stick input was also required. These aircraft motions were prevalent throughout the takeoff and climb at low speeds. At a lift-off of 70 KCAS the aircraft was relatively stable and control requirements were small after the aircraft was airborne.

2.4.2.4.3 Fan-Mode Takeoff Using a 30-Foot Level Flight Acceleration From a Hover

The aircraft had generally the same characteristics as those covered during the vertical lift-off discussion. A collective setting of approximately 40 percent was required to stabilize the aircraft in a hover at 30 feet. From the hover the longitudinal control was displaced forward from the trim position; this rotated the aircraft nose down and started the acceleration. As the aircraft rotated nose down the vectoring of the wing-fan louvers was started so that a continuation of the level acceleration could be accomplished. The collective control was also increased to maintain vertical thrust and prevent a loss in wheel height as the vector angle increased. The longitudinal stick moved forward during the acceleration. Pitch attitude reached the maximum nose-down value of 5 degrees and was maintained at this value until the climbout airspeed was reached. As climbout airspeed was reached a small amount of aft stick was applied to rotate the aircraft. Full-up collective was reached at an air-

speed of 32 KCAS. A small amount of directional motion was experienced which required pedal inputs of ±.5 inches. The directional stability became stronger as airspeed increased.

2.4.2.4.4 Fan-Mode Climb

The control requirements were small during a stabilized 600-foot/minute FM climb. At an airspeed of 52 KCAS and a near-level attitude, the high negative angle of attack did not introduce any significant adverse stability and control characteristics. Small random rate oscillations were experienced in pitch and roll. In many cases these were not large enough to cause a control input. Directional stability was strong with no apparent aircraft motion or pedal inputs required. The stability and control characteristics generally improved at increased climb speeds.

2.4.2.5 <u>Qualitative Pilot Comments</u>

2.4.2.5.1 Conventional Takeoff

Qualitatively the conventional takeoff and landing characteristics observed during this evaluation enhanced the flying qualities of the XV-5A. Two flap settings, zero percent and 25 percent, were investigated at various horizontal stabilizer positions. Of the horizontal positions investigated, -3.5 degrees and -2 degrees were optimum for takeoff with 25-percent and zero-percent flaps respectively. Approximate takeoff performance data observed for these configurations is shown in Table 3:

TABLE 3

[illegible]
TAKEOFF GROSS WEIGHT: [illegible]
PRESSURE ALTITUDE (ft): [illegible]

Indicated Flap (%)	Indicated Horizontal Stabilizer (deg)	[illegible]	[illegible]	[illegible]
0	-2	[illegible]	[illegible]	[illegible]
25	-3.5	[illegible]	[illegible]	[illegible]

*Runway heading: 220 degrees

The zero-percent flap takeoff was the more desirable of the two flap configurations investigated. With the zero-percent flap setting the pilot was able to rotate the aircraft 15 KIAS prior to the approximate lift-off speed of 125 KIAS. This procedure allowed a smooth transition from takeoff roll to takeoff climb. With 25-percent flaps extended, aircraft rotation and lift-off occurred simultaneously at approximately 110 KIAS. The stick forces required to initiate rotation were high (approximately 25 pounds) during rotation but returned to trim at lift-off.

Directional control during takeoff ground run was effortless. Rudder effectiveness was noted at approximately 40 KIAS and aileron effectiveness was noted at 80 KIAS. During early flights there was a tendency toward pilot-induced lateral oscillations during climbout. As flight experience in the test aircraft was obtained, this lateral over-control tendency was easily eliminated. A pilot opinion rating of 2.5 was assigned to the conventional takeoff characteristics observed during this evaluation.

An associated problem encountered during conventional takeoff and climbout was overheating of the right wing-fan cavity area. To reduce the cavity area below its over-temp condition (120 degrees C) engine rpm had to be retarded to approximately 96 percent. This requirement constituted a performance limitation. Correction of this item is mandatory for follow-on XV-5A aircraft. Recommendation 1.7.1f

2.4.2.5.2 Conventional Landing

The conventional landing characteristics observed without crosswind or turbulence were satisfactory. The narrow-track landing-gear geometry, low-power brakes and large aircraft side area all contributed to the poor crosswind landing characteristics exhibited. In landing winds of less than 5-knot direct crosswind component, landing attitudes were characterized by large compensating bank angles into the wind required to maintain desired ground track. Immediately after touchdown the aircraft tended to turn downwind; this required total pilot attention to correct with rudder and brake control. These results were undesirable and would severely limit the conventional operational capabilities of any XV-5 model aircraft. With 25-percent flaps, normal landing approaches were flown at an approximately 12-degree angle of attack (130 KIAS) and 85-percent engine rpm. Under these conditions, touchdown occurred at a 15-degree angle of attack (110 KIAS). The aircraft was firm on landing and exhibited no tendency to bounce or float during touchdown. Aerodynamic braking was possible by holding the nosewheel off the ground until approximately 85 KIAS when insufficient elevator effectiveness was available to hold the nosewheel off.

"Wave-off" characteristics from normal approaches were excellent with no loss of altitude required. A pilot opinion rating of 3.5 was assigned to the XV-5A's conventional landing characteristics. Recommendation 1.7.2i

2.4.2.5.3 Level Acceleration From a 30-Foot Hover

At 30-foot wheel height the aircraft provided a steady platform. No retrimming was required following landing gear retraction. Initial acceleration with a 5-degree nose-down pitch attitude was comfortable and altitude was easily maintained with the raising of the lift stick. During initial acceleration with vectoring of the wing-fan louvers, specific attention was required to insure that a "rule-of-thumb" relationship of 2 KIAS of airspeed for each degree of louver angle was maintained. If louver angle exceeded the 1:2 relationship with airspeed prior to 40 KIAS, a loss of lateral control power was observed. The lateral control power loss was attributed to the "washout" of fan control power as louver angle approached the maximum FM configuration setting of 45 degrees. The problem was confined to the lateral axis due to the previously discussed (Paragraph 2.4.1.5) severe degradation of lateral control power in FM configuration with full-up lift stick. At airspeeds greater than 40 KIAS, sufficient aerodynamic lateral control power was available from ailerons to allow small deviations from the 1:2 relationship between louver angle and airspeed. These results, specifically at airspeeds less than 40 KIAS, were undesirable. A high degree of pilot attention was required to maintain the louver angle-airspeed schedule, especially at airspeeds below 40 KIAS. A pilot opinion rating of 5 was assigned to louver angle-airspeed requirement observed during level flight acceleration from a 30-foot hover in FM configuration. Recommendation 1.7.2h

Longitudinal trim requirements during acceleration could not be satisfied due to insufficient aircraft nose-down trim authority. This characteristic, previously noted in Paragraph 2.2.1.5.1, detracted from the longitudinal flying qualities of the XV-5A in FM configuration. Correction of this shortcoming is desirable for future XV-5 aircraft. Recommendations 1.7.2f, h

2.4.2.5.4 Ground-Run Acceleration

The ground-run acceleration technique, as described in Paragraph 2.4.2.2b, was unsatisfactory for a takeoff airspeed of 45 KIAS. It was not possible to devector from a louver angle of 45 degrees to 25 degrees prior to obtaining the desired 45-KIAS takeoff speed. The net result was an early lift-off, lift stick raised to 100 percent, at 50 KIAS with a louver angle setting of

23 degrees. Although not attempted, takeoffs at airspeeds below 45 KIAS might very well result in the situation of insufficient available control power discussed in Paragraph 2.4.1.5. The ingredients for this control problem are all present during a low-speed takeoff (below 45 KIAS): high lift stick, louver angle setting greater than 20 degrees, and airspeed below 45 KIAS. For takeoffs at airspeeds greater than 45 KIAS the ground-run acceleration technique was adequate but required over 1000 feet of runway to accomplish at a gross weight that was suitable for a vertical lift-off. From these results it was concluded that the technique used for ground-run accelerations during this evaluation was not satisfactory.

2.4.2.5.5 Fan-Mode Climb

No objectionable flight characteristics were observed during the conduct of this portion of the evaluation. A looseness of lateral and directional control was noted during FM climbs at 30 KIAS, as compared with handling qualities observed during climbs at higher airspeeds. Qualitatively the 40-KIAS climb provided maximum climb rates. Climbs at 70 KIAS produced negligible climb rates (less than 300 feet per minute). A pilot opinion rating of 3 was assigned to the XV-5A flying qualities observed during climbs in FM configuration.

2.4.3 CONVERSIONS

2.4.3.1 Objective

The objective of these tests was to evaluate the control requirements, stability, and pilot effort during a conversion at altitude from jet mode to fan mode and vice versa.

2.4.3.2 Method

Attitude conversions were performed at various flight conditions. The control inputs, rates, and attitudes were recorded prior to and during each conversion. All conversions were performed with the collective full up.

2.4.3.3 Test Results

The results are summarized graphically in Figures 133 through 135, Appendix I.

2.4.3.4 Quantitative Engineering Analysis

2.4.3.4.1 Conversion from Jet Mode to Fan Mode

Stability characteristics and control requirements were significantly influenced by the airspeed at conversion. The lateral stability was considerably weaker at 102 KCAS than at 120 KCAS. Following the start of the conversion a characteristic nose-down pitching motion occurred which was more rapid and of a larger magnitude at high speeds. Angle of attack and normal acceleration immediately decreased and aft longitudinal stick was required following the conversion.

At an airspeed of 102 KCAS an immediate nose-down pitch rate occurred. Pitch attitude started to change approximately .5 seconds after the initiation of the conversion and at this time aft stick was applied to control the pitch rate. Approximately 1.5 inches of stick was used to control the initial pitching. During this time the angle of attack decreased 4 degrees and the normal acceleration became .6 g. In the latter portion of the conversion sequence, the horizontal stabilizer programmed to 10 degrees trailing edge down. This introduced nose-down pitching moment that required an additional 1.7 inches of aft longitudinal control. As the stabilizer programmed, the maximum nose-down pitch rate of 15 degrees/second was reached. Attitude became 3.5 degrees nose down and the normal acceleration was .4 g. As the conversion was completed there was lateral oscillation which required some lateral stick inputs. The SAS motions opposed the pitch-down and the lateral oscillation. The total aft stick requirement was 3.4 inches. This aft position was maintained until a nose-up rate was established and the angle of attack was near zero. The stick was then moved forward 1.5 inches. There were no yawing motions or requirement for pedal input during the conversion.

Conversion at an airspeed of 120 KCAS was basically the same as the conversion at 102 KCAS. The initial pitch-down was sharper and required a more rapid aft stick input. As the horizontal stabilizer programmed, more aft stick was required to achieve attitude and angle-of-attack conditions similar to those at the lower airspeed. It was also necessary to maintain the aft stick position for a considerably longer period to complete the conversion and achieve an FM level flight condition. The deceleration after the conversion was much greater than at the lower airspeed and was fairly constant at 1 knot/second. The lateral stability was considerably stronger and no yawing motion was evident during the conversion.

2.4.3.4.2 Conversion From Fan Mode to Jet Mode

Stability characteristics and control requirements were positive and small in magnitude during conversion. Following the start of conversion a characteristic nose-up pitching motion

occurred. This pitching motion was caused by the programming of horizontal tail to 5 degrees trailing edge up. This aircraft motion required a forward stick displacement to check the pitching rate.

At a conversion speed of 90 KCAS an immediate nose-up pitching motion occurred. This change in pitch attitude was caused by the programming of the horizontal tail to the 5-degree trailing-edge-up position. Pitch attitude started to change approximately .25 seconds after the initiation of conversion. Forward longitudinal stick displacement was applied to check the pitch-up rate. During the conversion the longitudinal stick traveled from .6 inches aft of neutral to 4.0 inches forward of neutral. The time required for this stick motion was 2.0 seconds. In the latter portion of the conversion sequence, the longitudinal control was returned to a position about 2 inches forward of neutral. The lateral and directional control inputs required during the conversion were very small.

2.4.3.5 Qualitative Pilot Comments

2.4.3.5.1 Conversion

The conventional-to-fan-powered-flight conversion characteristics enhanced the XV-5A's flying qualities. Conversions were conducted in level flight at the following conditions: engine RPM (97 percent - 100 percent), density altitude (4500 feet-8500 feet), and airspeed (95 KIAS - 105 KIAS). All conversions were characterized by a mild pitch-over (from +13 degrees α to +5 degrees α) which required approximately 15 pounds of aft stick force to arrest without an altitude loss. A sensation of deceleration, similar to that following the extension of speed brakes in a conventional aircraft, was the most prominent "cockpit cue" of conversion. Additional cockpit cues were: horizontal stabilizer visual and aural signals' denoting the programmed movement of the stabilizer to the 10-degree leading-edge-up position, visual signal's denoting diverter valve in the lift-fan position and increased noise level due to the three fans' coming up to speed. The increased noise level was of such magnitude that radio communications were impaired unless the pilot wore a snugly fitted flying helmet and oxygen face mask. Total time required for the conversion was approximately 3 seconds. The major changes that occurred during conversions are shown in Table 4:

[illegible]		
	Before (Zero Time)	[illegible]
J-85-5A RPM	97% - 100%	[illegible]
Wing-Fan RPM	Zero %	[illegible]
Nose-Fan RPM	Zero %	[illegible]
Horizontal Stabilizer	-5° to -3° LED	+10° [illegible]
Angle of Attack	+12° α to +15° α	[illegible]
Wing-Fan Doors	Closed	Open
Airspeed	95 KIAS to 105 KIAS	[illegible]
Configuration	Pre-Conversion	Fan-[illegible]

The pertinent components that remained unchanged are shown in Table 5:

TABLE 5		
	Before (Zero Time)	(Zero [illegible])
Flaps	Full down (100%)	Full [illegible]
Nose-Fan Intake & Exit Doors	Open	Open
Wing-Fan Exit [illegible]	-45°	[illegible]

The technique employed to satisfy the "before-conversion" condition of high engine RPM and low airspeed was initially to stabilize the aircraft in pre-conversion (PC) configuration at the desired airspeed (95 KIAS to 105 KIAS); this required approximately 88 percent to 92 percent of engine RPM. Immediately preceding selection of the fan-power mode switch, engine RPM was advanced to the desired magnitude (97 percent - 100 percent). Aircraft airspeed accelerations prior to conversion were between

1 KIAS and 5 KIAS, depending upon pilot quickness in performing these tasks. To correct this shortcoming, it is recommended that follow-on XV-5A aircraft be provided with speed brakes to assist the pilot during this phase of the conversion. The optimum conventional-to-fan-powered-flight conversion, of those conversions observed, was accomplished under the conditions noted in Table 6:

[illegible]		
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	100% ±
[illegible]	[illegible]	100% ±
[illegible]	[illegible]	100% ±
Horizontal Stabilizer	[illegible]	[illegible]
Angle of Attack	[illegible]	0°
Airspeed	95 KIAS	85 KIAS
Density Altitude*	[illegible] ft	[illegible] ft

*Conversions at higher density altitudes produced sink rates following conversions.

A pilot opinion rating of 2.5 was assigned to the conventional-to-fan-powered-flight conversion characteristics observed during this evaluation. Recommendation 1.7.2k

A pilot opinion rating of 2 was assigned to the fan-power-to-conventional-flight conversion characteristics observed during this evaluation. Wings-level conversions were conducted both in level flight and during descents at airspeeds between 85 KIAS and 95 KIAS. All conversions were characterized by immediate acceleration and mild pitch-up that could be arrested with a 10-percent engine power reduction (100 percent to 90 percent). No specific control movement, other than throttle reduction, was required to maintain flight attitude following the conversion. The sensation of immediate acceleration was the most prominent "cockpit cue" of the conversion. Additional cues were: horizontal stabilizer visual and aural signals' denoting the programmed movement of the stabilizer to the -5 degree leading-edge-down position, the visual signal's denoting diverter valve in the conventional powered position and the decreased cockpit noise level. Total time required for the conversion was approximately 1 second. These conversion characteristics, as observed during this evaluation, enhanced the flying qualities of the XV-5A.

2.4.4 TRANSITION CHARACTERISTICS WITH STABILITY AUGMENTATION SYSTEM INOPERATIVE

2.4.4.1 Objective

The objective of these tests was to evaluate the stability characteristics of the aircraft and the increase in pilot effort with the SAS inoperative.

2.4.4.2 Method

The aircraft with the SAS inoperative was evaluated by increasing speed from a hover to 32 KCAS and by converting to fan mode at altitude.

A forward translation was started by vectoring aft with the aircraft in a hover condition. Control inputs were made to maintain a constant-heading wings-level attitude. Data were recorded during this forward translation.

A conversion from JM to FM flight was conducted at altitude. After the aircraft was converted to fan mode the aircraft was devectored to a speed of approximately 40 KCAS. The aircraft was then accelerated to a speed of 87 KCAS and converted back to JM flight. Control inputs, rates, attitudes, etc, were recorded during the entire test.

2.4.4.3 Test Results

The results are summarized graphically in Figures 136 through 137, Appendix I.

2.4.4.4 Quantitative Engineering Analysis

2.4.4.4.1 Conversion and Transition with the SAS Inoperative

Stability characteristics and control requirements during a SAS-off conversion were essentially the same as those for a SAS-on condition. This indicated that although the SAS provided an input at high speeds, the fan controls were not effective at this condition. Following the conversion, airspeed was decreased by devectoring and a lateral-directional oscillation was encountered. The period of the oscillation was 2 seconds and the magnitude increased as the devectoring was continued. Lateral control inputs were applied to oppose the motion, the magnitude being ±2 inches at 40 KCAS. Random pitching motions which required ±.75 inches of longitudinal stick were also present. Stability continued to deteriorate

with decreased airspeed and random aircraft motions and stick inputs were experienced at 35 KCAS. No significant pedal inputs were required during the conversion and devectoring.

The stability during an acceleration from 35 KCAS was considerably better than during the deceleration. The lateral-directional oscillation was present but was greatly reduced. During the vectoring process a power cutback was experienced at an airspeed of 80 KCAS. The engine power was reduced from 101 to 98 percent and the wing-fan speed decreased from 102 to 96 percent. This power cutback required 2 inches of aft stick to compensate for the reduction in pitching moment associated with power reductions at the airspeeds in transition. No roll or yawing motions were associated with the power cutback. The power was reset and the vectoring continued to the conversion speed. The stability characteristics during the conversion to jet mode were similar to those for the SAS-on condition.

Lateral stability was weak during an acceleration from hover to 30 KCAS. Immediately after the vectoring was started there was a lateral oscillation. This oscillation increased with airspeed and reached a maximum at 8 KCAS. At this point the attitude change was ±8 degrees. The stability improved as airspeed was further increased and the oscillation was damped. The longitudinal and lateral control inputs were frequent and small in magnitude. The longitudinal stability was positive and the longitudinal stick moved slowly forward during the acceleration. Pedal requirements were similar to those for the SAS-on configuration. Recommendation 1.7.3i

2.4.4.5 Qualitative Pilot Comments

No objectionable characteristics were encountered during conversion since the SAS was "phased" out. Reference Paragraph 2.4.1.5 for variable SAS investigation during a hover. Recommendation 1.7.3i

SECTION 3 — Appendices

APPENDIX I — Test Data

FIGURE NO. 1

SUMMARY OF LONGITUDINAL BREAKOUT FORCE AND FORCE GRADIENT

XV-5A USA S/N 62-4505

FAN MODE

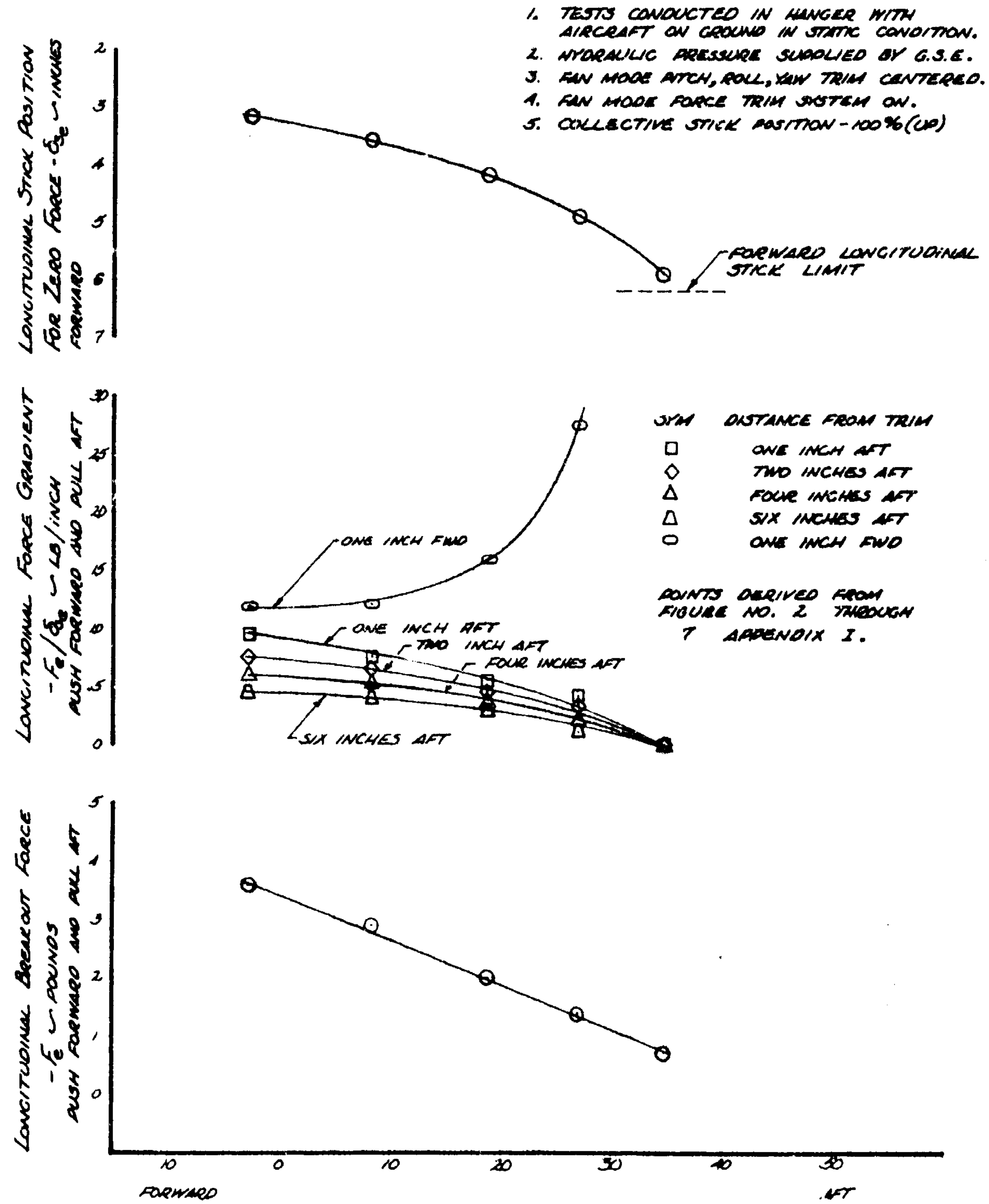


FIGURE No. 2
LONGITUDINAL STICK FORCE
XV-5A USA S/N 62-4505
FAN MODE
BETA VECTOR POSITION = 2.7 DEG. FWD.

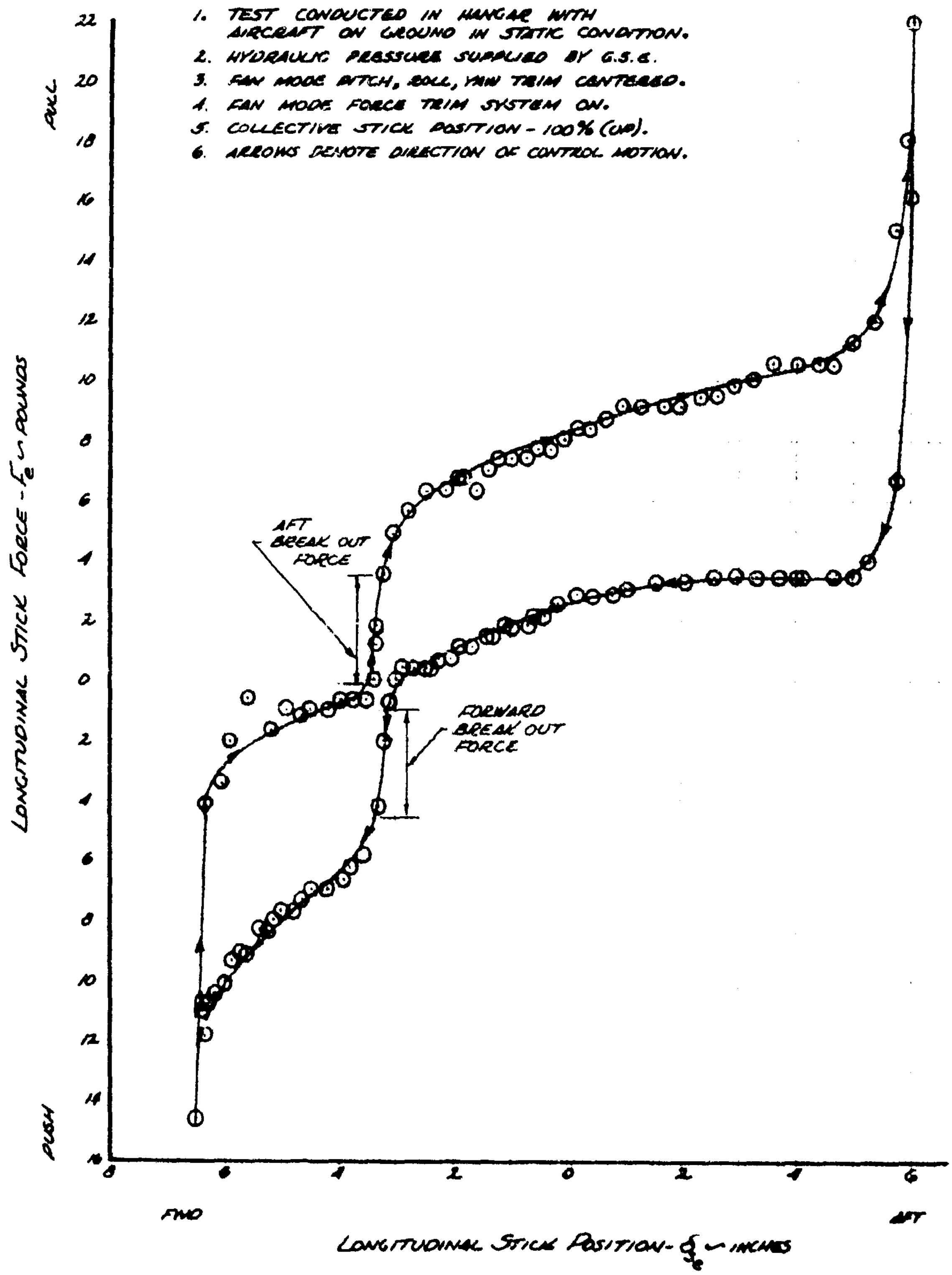


FIGURE No. 3
LONGITUDINAL STICK FORCE
XV-5A USA S/N 62-4505
FAN MODE
BETA VECTOR POSITION = 8.3 DEG. AFT.

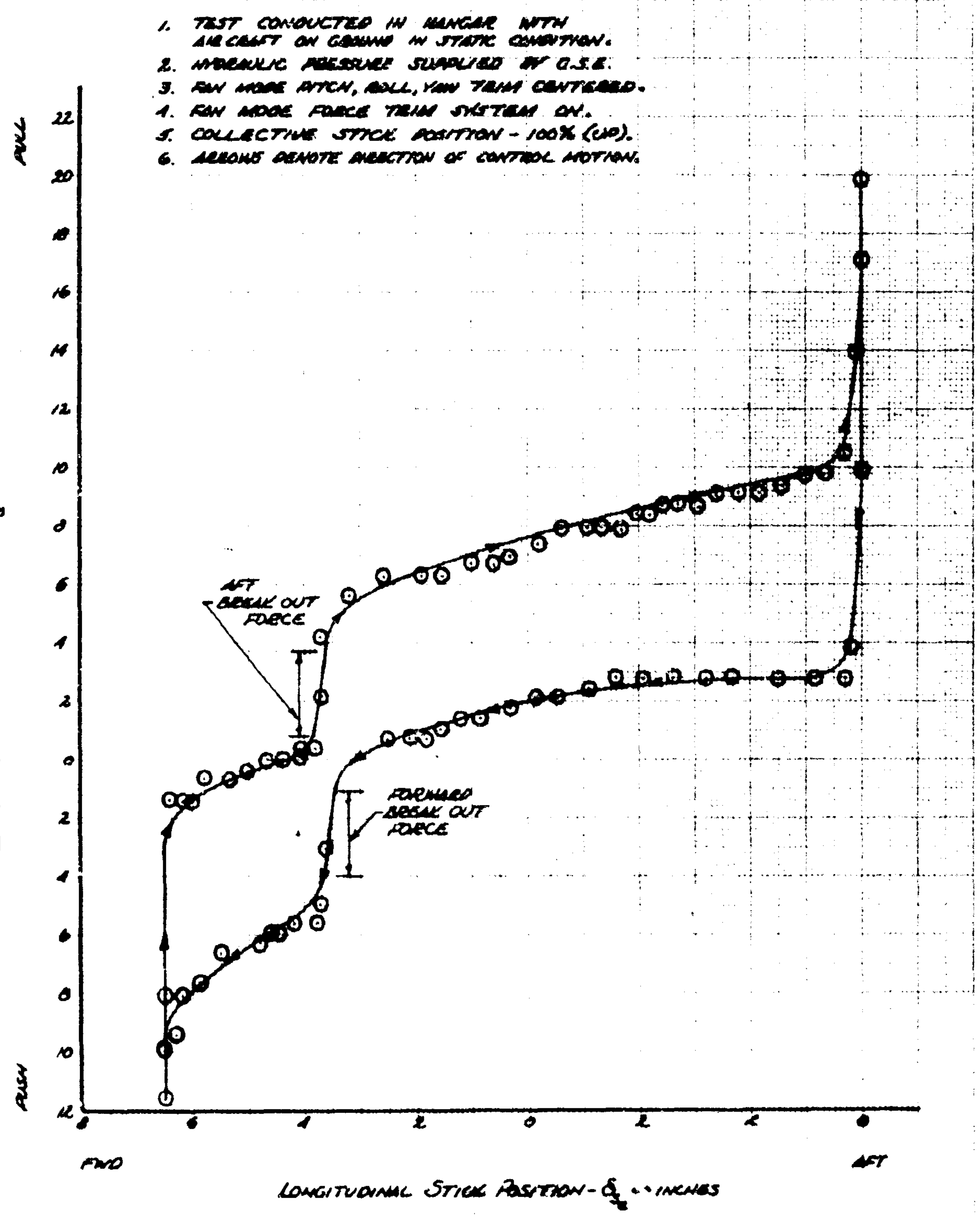


FIGURE No. 4
LONGITUDINAL STICK FORCE
XV-5A USA S/N 62-4505
FAN MODE
BETA VECTOR POSITION = 18.9 DEG AFT.

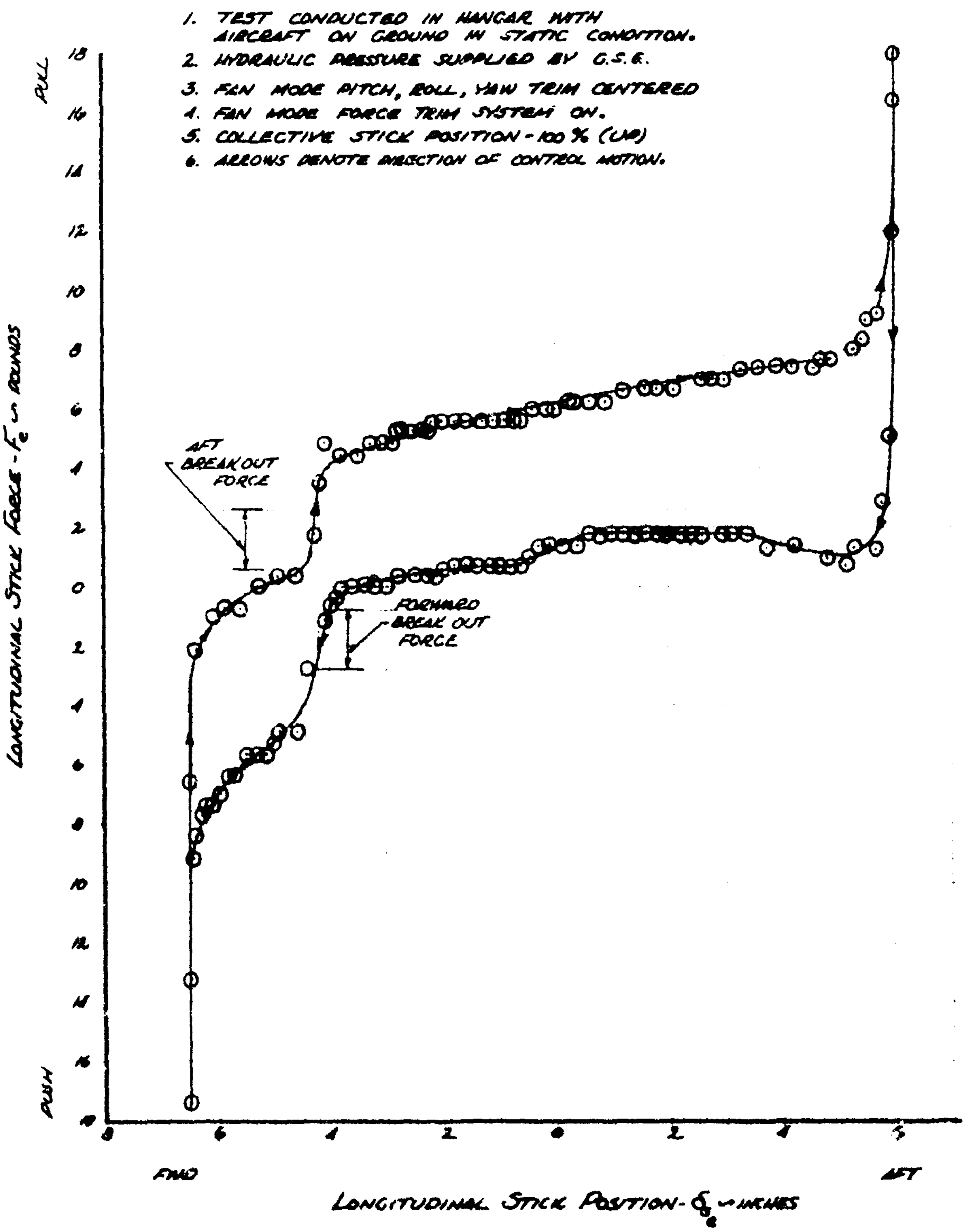


FIGURE No. 5
LONGITUDINAL STICK FORCE
XV-5A USA S/N 62-4505
FAN MODE
BETA VECTOR POSITION = 26.8 DEG. AFT.

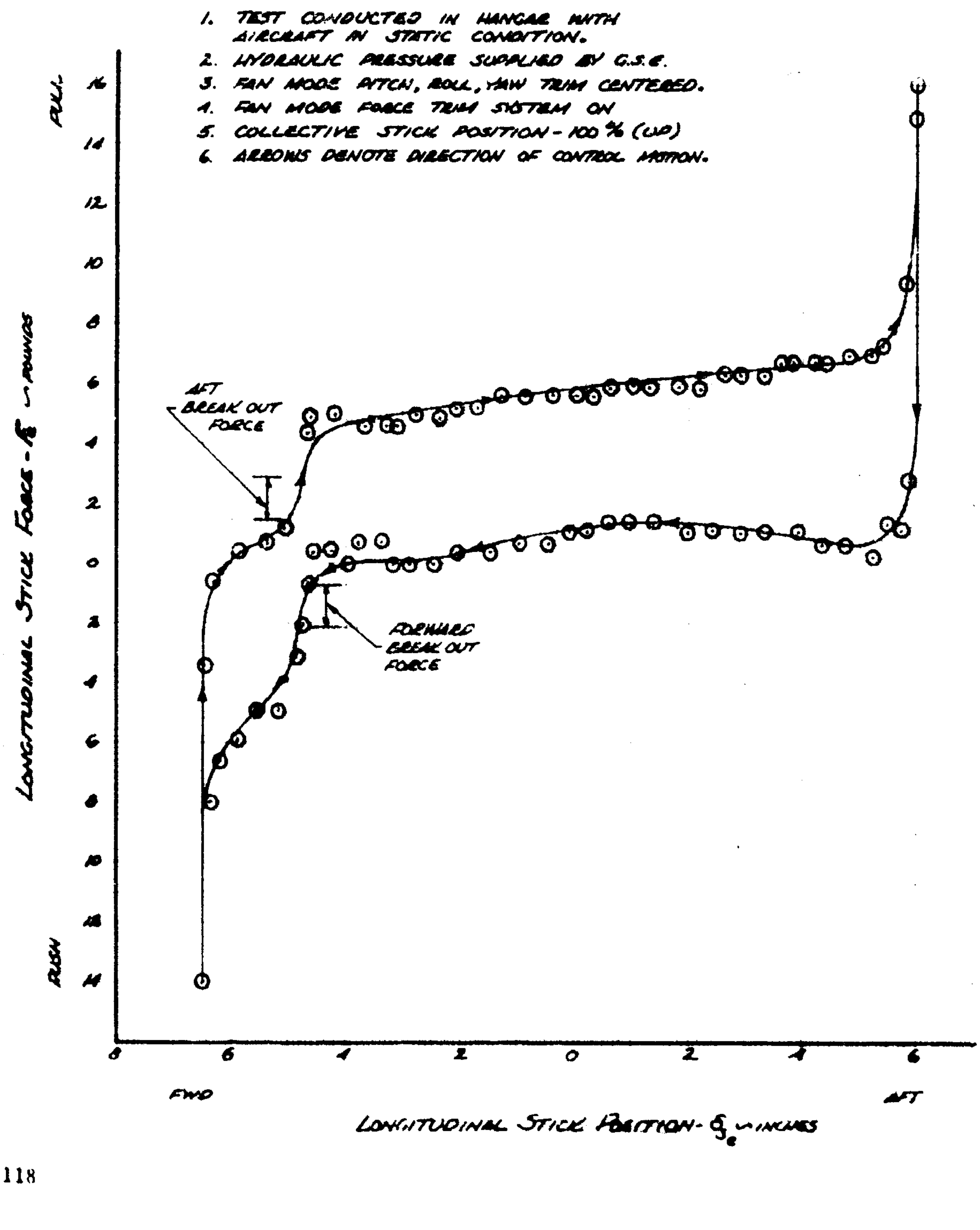


FIGURE No. 6
LONGITUDINAL STICK FORCE
XV-5A USA S/N 62-4505
FAN MODE
BETA VECTOR POSITION = 34.6 DEG. AFT.

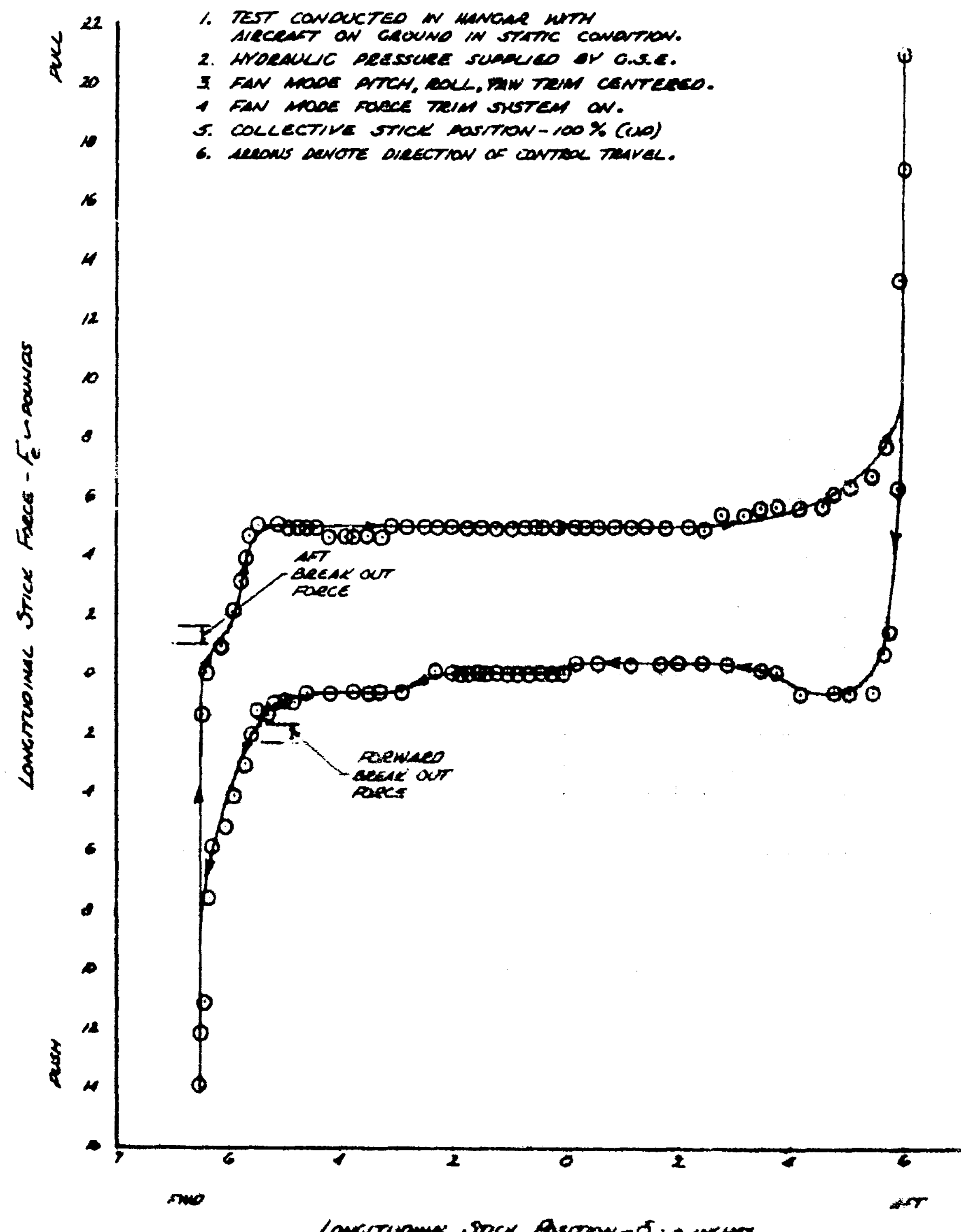


FIGURE No. 7
LONGITUDINAL STICK FORCE
XV-5A USA S/N 62-4505

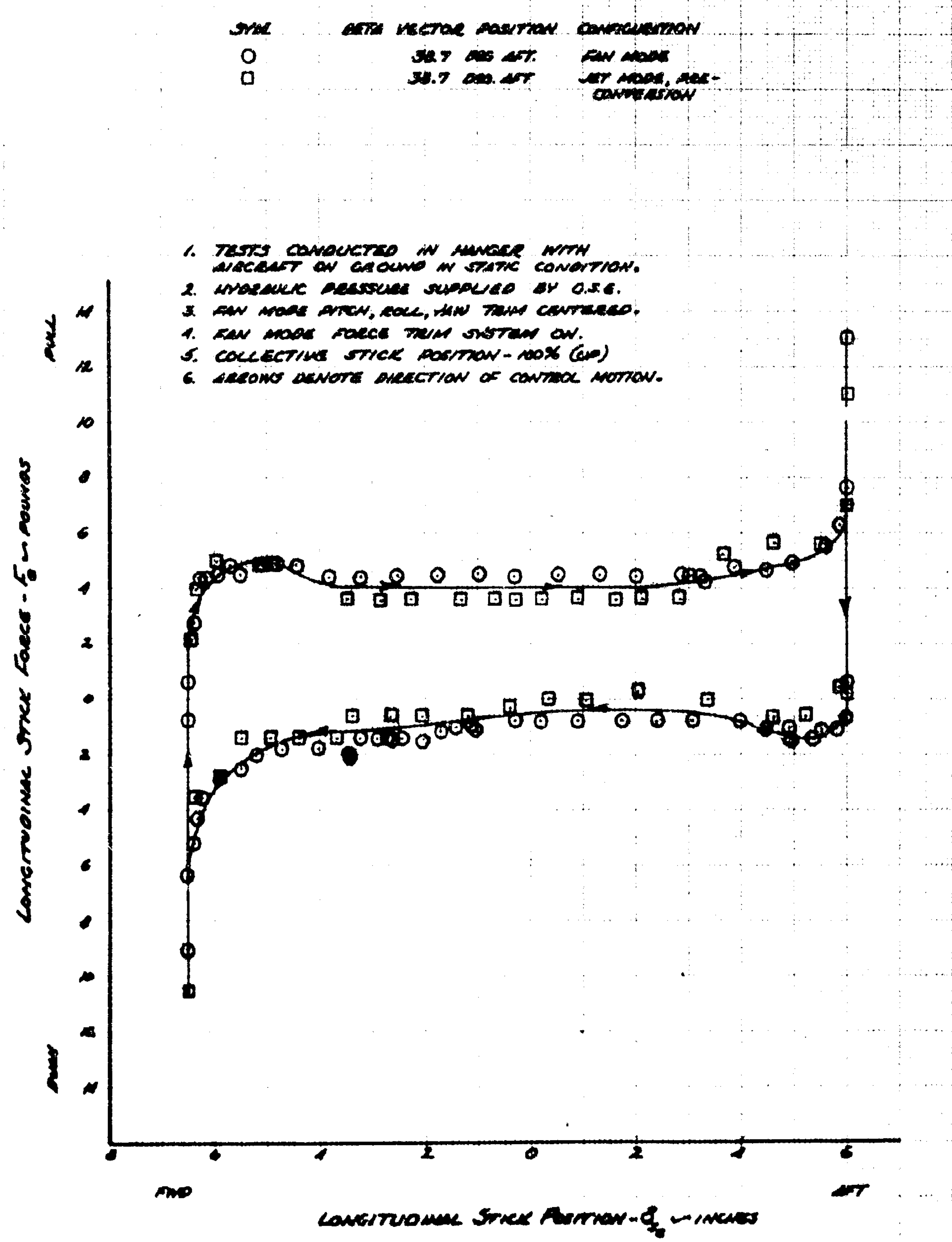


FIGURE No. 8

SUMMARY OF LATERAL CONTROL
BREAKOUT FORCES AND FORCE GRADIENTS

XV-5A USA S/N 62-4505

FAN MODE

1. TESTS CONDUCTED IN HANGAR WITH AIRCRAFT ON GROUND IN STATIC CONDITION.
2. HYDRAULIC PRESSURE SUPPLIED BY G.S.E.
3. FAN MODE PITCH, ROLL, YAW TRIM CENTERED.
4. FAN MODE FORCE TRIM ON.
5. COLLECTIVE STICK POSITION - 100 % (UP)

SYM	DISTANCE FROM TRIM
□	ONE INCH LEFT AND RIGHT
△	TWO INCHES LEFT AND RIGHT

POINTS DERIVED FROM FIGURE NO. 8 THROUGH 14 APPENDIX I.

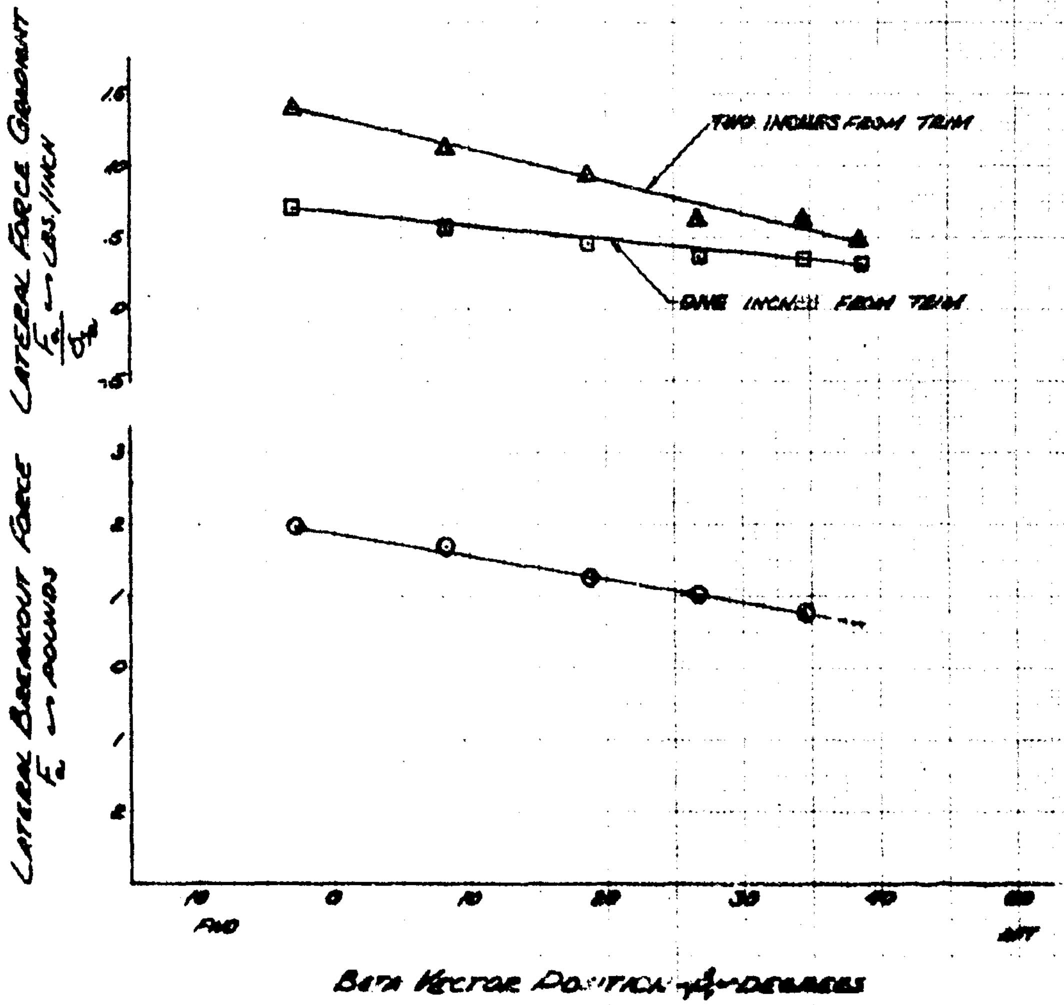


FIGURE No. 9
LATERAL STICK FORCE
XV-5A USA S/N 62-1505
FAN MODE
BETA VECTOR POSITION = 2.7 DEG. FWD.

1. TEST CONDUCTED IN HANGAR WITH AIRCRAFT ON GROUND IN STATIC CONDITION.
2. HYDRAULIC PRESSURE SUPPLIED BY G.S.E.
3. FAN MODE PITCH, ROLL, YAW TRIM CENTERED.
4. FAN MODE FORCE TRIM SYSTEM ON
5. COLLECTIVE STICK POSITION - 100 % (UP)
6. ARROWS DENOTE DIRECTION OF CONTROL MOTION.

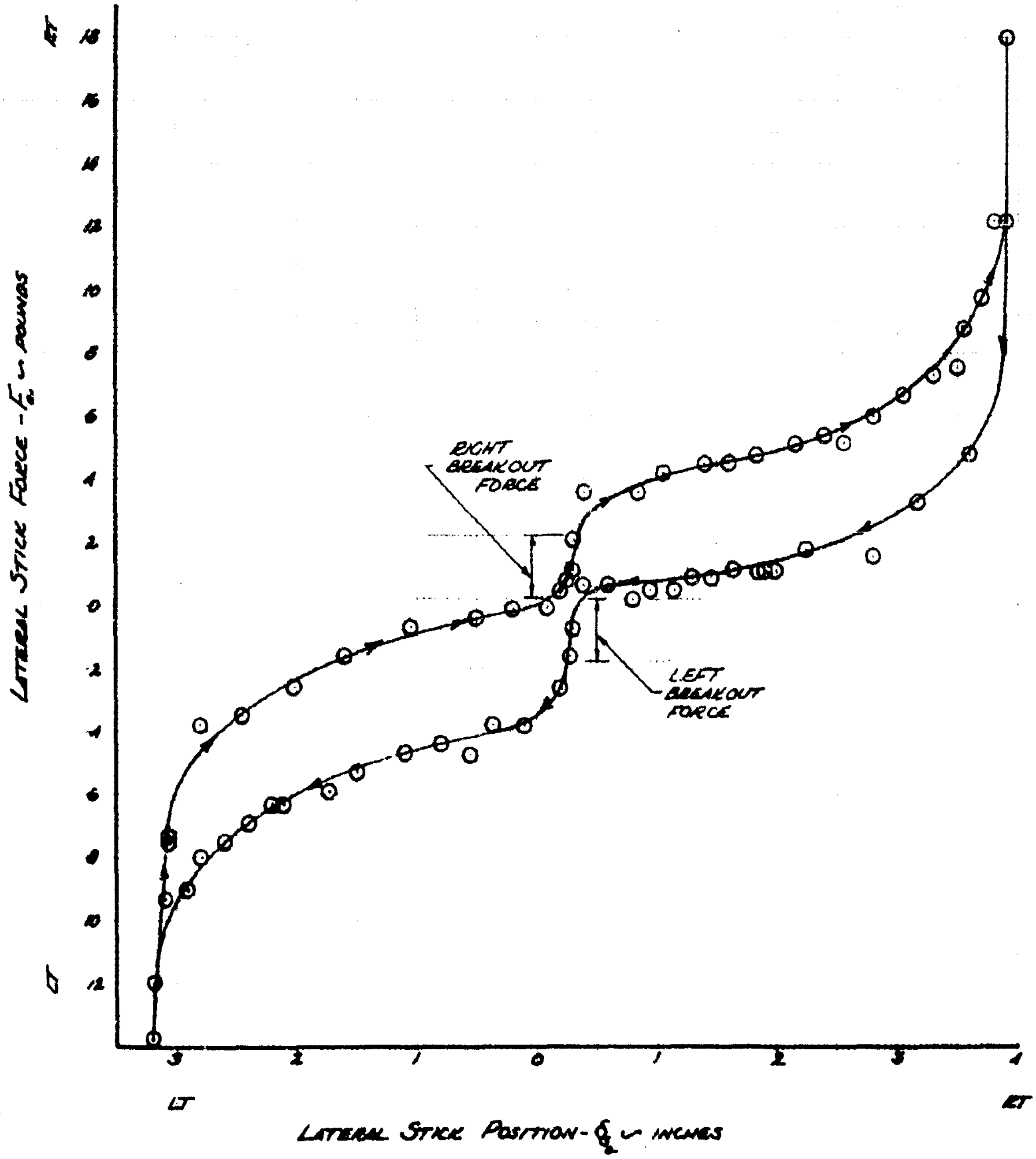


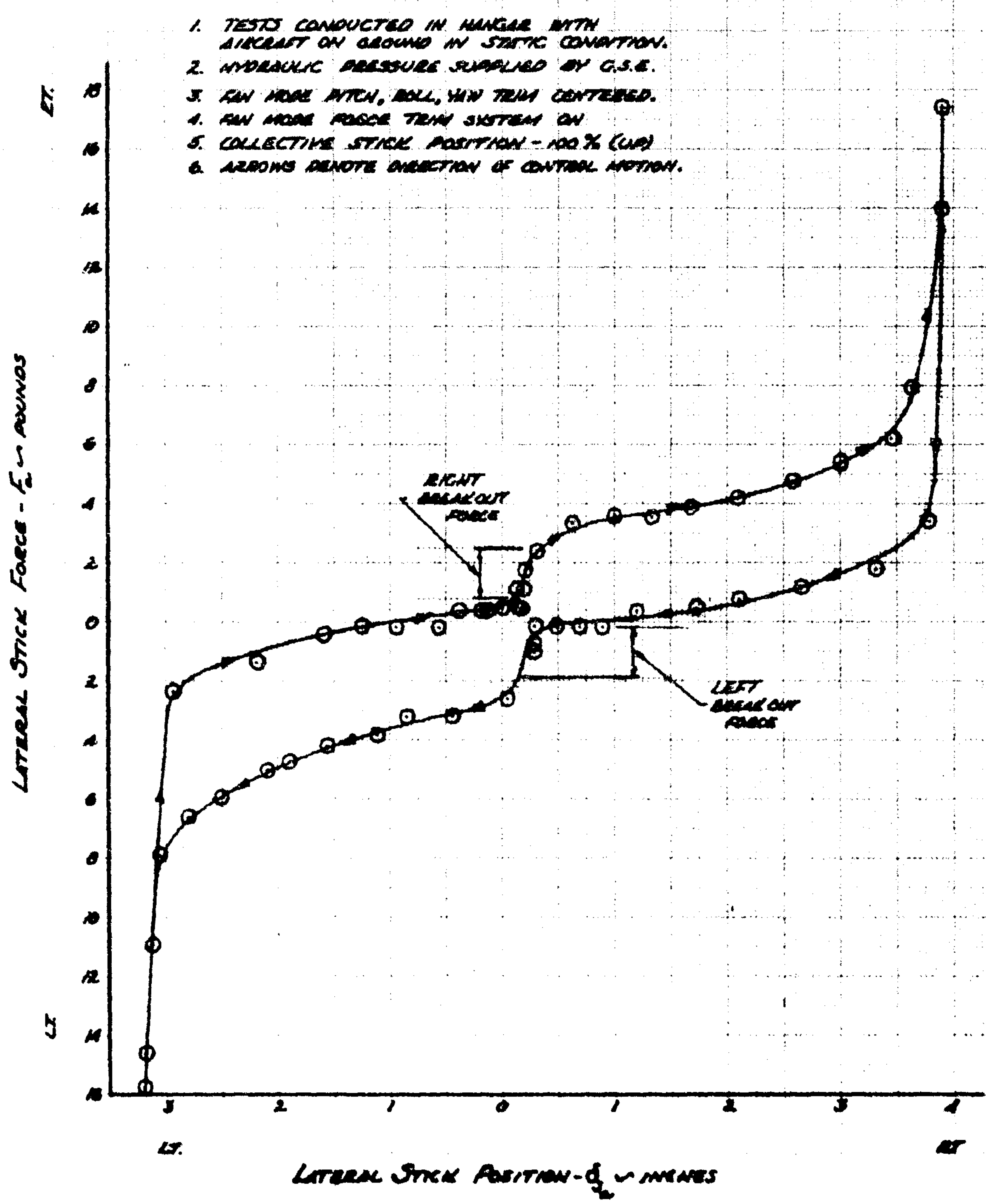
FIGURE No. 10

LATERAL STICK FORCE

XV-5A USA S/N 62-4505

FAN MODE

BETA VECTOR POSITION = 8.5 DEG. AFT



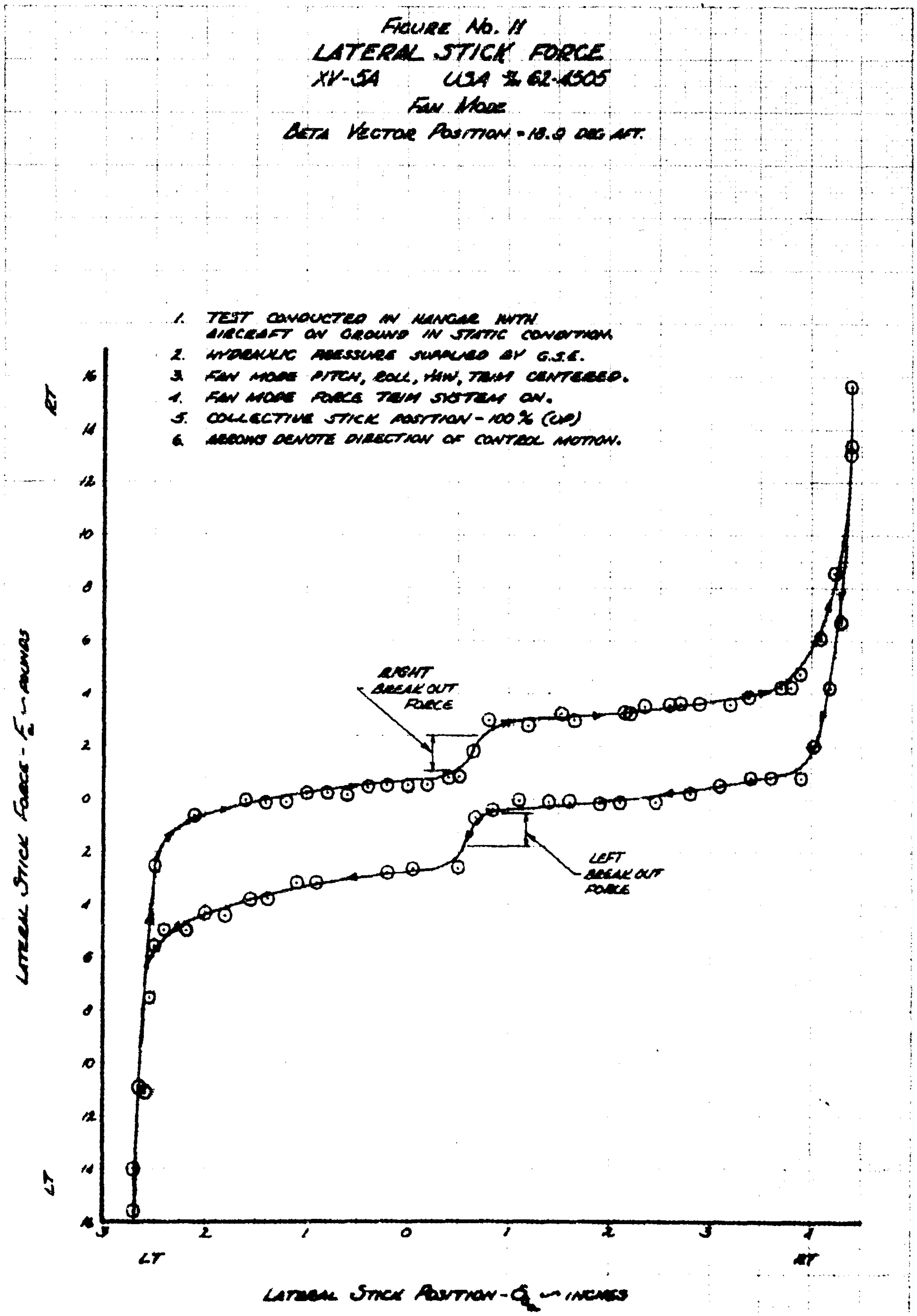


FIGURE No. 11
LATERAL STICK FORCE
XV-5A USA S/N 62-4505
FAN MODE
BETA VECTOR POSITION = 18.0 DEG AFT.
1. TEST CONDUCTED IN HANGAR WITH AIRCRAFT ON GROUND IN STATIC CONDITION.
2. HYDRAULIC PRESSURE SUPPLIED BY G.S.E.
3. FAN MODE PITCH, ROLL, YAW, TRIM CENTERED.
4. FAN MODE FORCE TRIM SYSTEM ON.
5. COLLECTIVE STICK POSITION - 100% (UP)
6. ARROWS DENOTE DIRECTION OF CONTROL MOTION.
RIGHT BREAK OUT FORCE
LEFT BREAK OUT FORCE
LATERAL STICK FORCE - F_a ~ POUNDS
RT
LT
LATERAL STICK POSITION - δ_a ~ INCHES

FIGURE No. 12
LATERAL STICK FORCE
XV-5A USA S/N 62-4505
FAN MODE
BETA VECTOR POSITION = 26.8 DEG. AFT

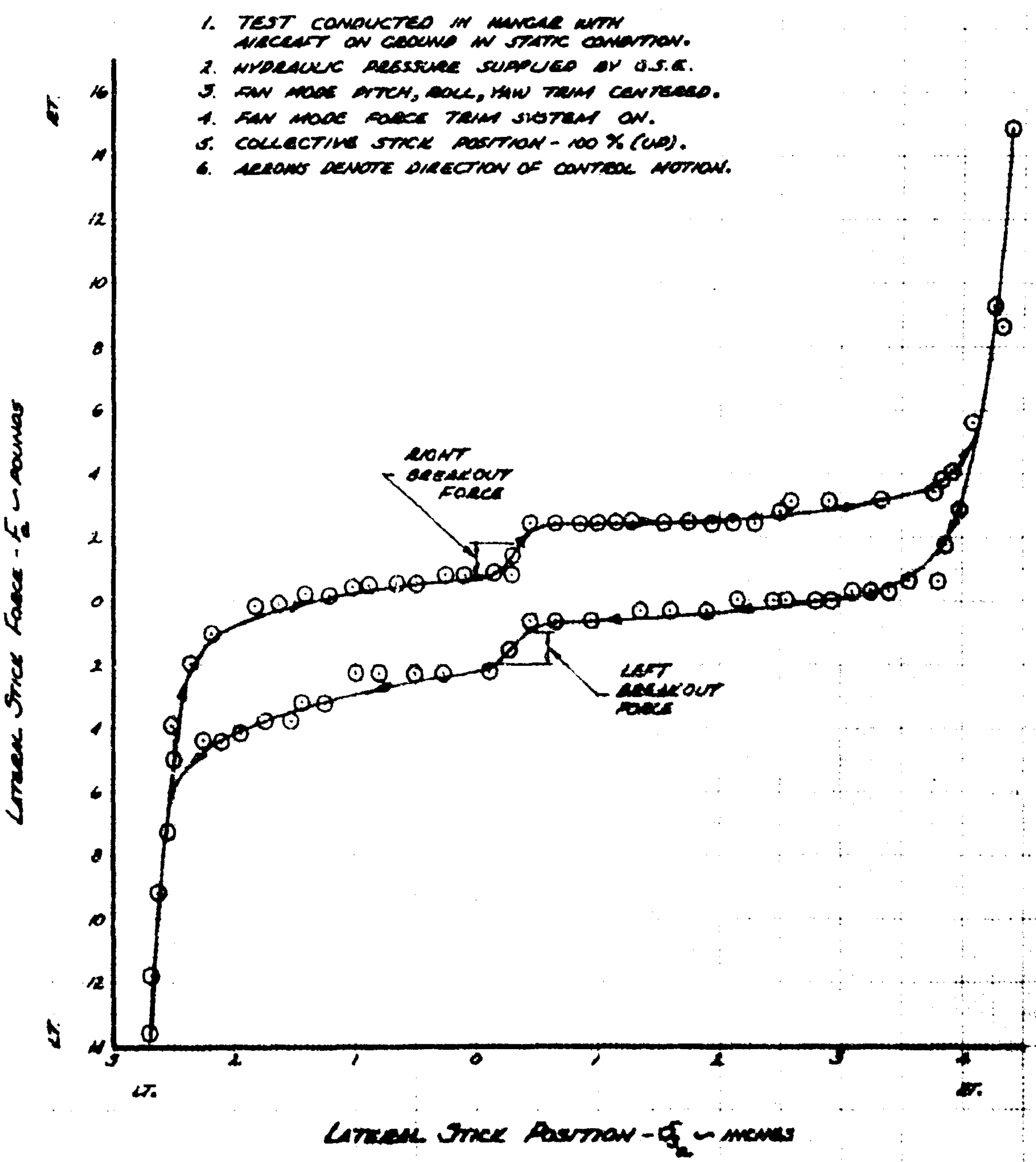


FIGURE No. 13
LATERAL STICK FORCE
XV-5A USA S/N 62-4505
FAN MODE
BETA VECTOR POSITION = 34.6 DEG. AFT.

1. TEST CONDUCTED IN HANGAR WITH AIRCRAFT ON GROUND IN STATIC CONDITION.
2. HYDRAULIC PRESSURE PROVIDED BY G.S.E.
3. FAN MODE PITCH, ROLL, YAW TRIM CENTERED.
4. FAN MODE FORCE TRIM SYSTEM ON.
5. COLLECTIVE STICK POSITION - 100% (UP)
6. ARROWS DENOTE DIRECTION OF CONTROL MOTION.

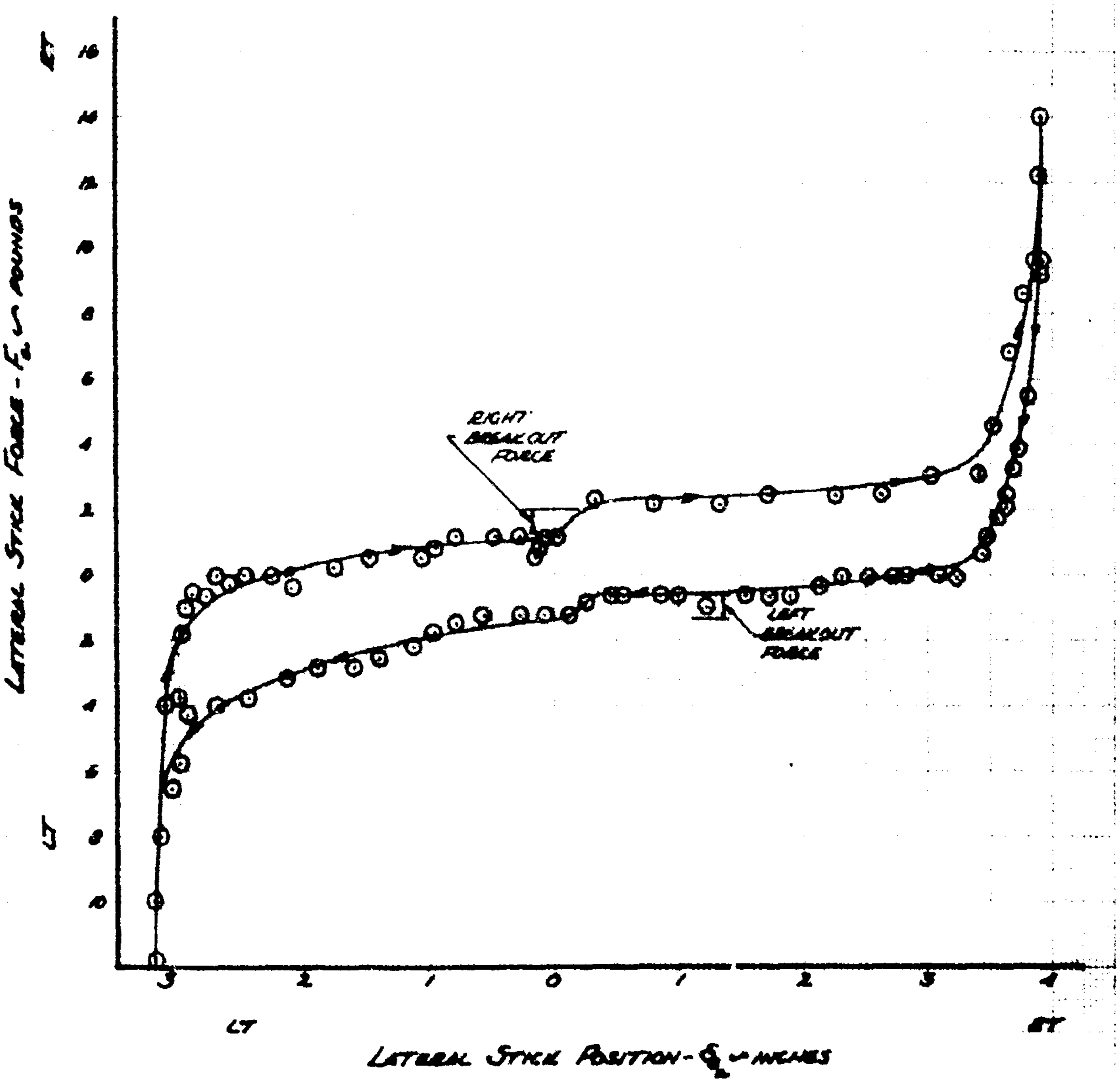


FIGURE No. 14
LATERAL STICK FORCE
XV-5A USA S/N 62-4505

SYM	BETA VECTOR POSITION	CONFIGURATION
○	38.7 DEG AFT	FAN MODE
□	38.7 DEG AFT	JET MODE - PRE-CONVERSION

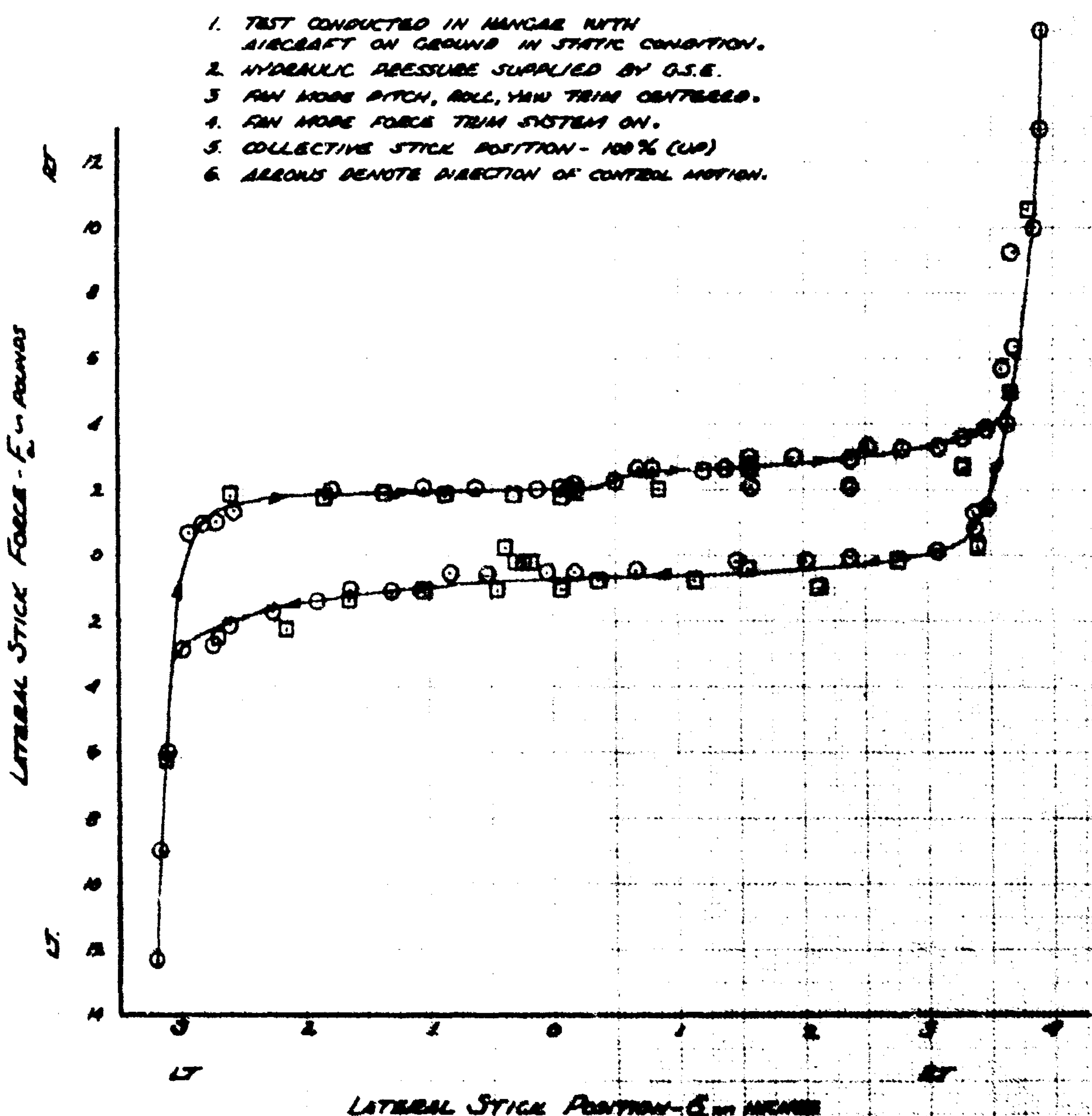


FIGURE No. 15
SUMMARY OF DIRECTIONAL BREAKOUT
FORCE AND FORCE GRADIENT
XV-5A USA S/N 62-4505
FAN MODE

1. TEST CONDUCTED IN HANGAR WITH AIRCRAFT ON GROUND IN STATIC CONDITION.
2. HYDRAULIC PRESSURE SUPPLIED BY GSE.
3. FAN MODE PITCH, ROLL, YAW TRIM CENTERED.
4. FAN MODE FORCE TRIM SYSTEM ON.
5. COLLECTIVE STICK POSITION - 100% (UP).

SYM	DISTANCE FROM TRIM
△	ONE INCH LEFT AND RIGHT
◇	TWO INCHES LEFT AND RIGHT
□	THREE INCHES LEFT AND RIGHT

POINTS DERIVED FROM FIGURE NO. 16 THROUGH 21 APPENDIX I.

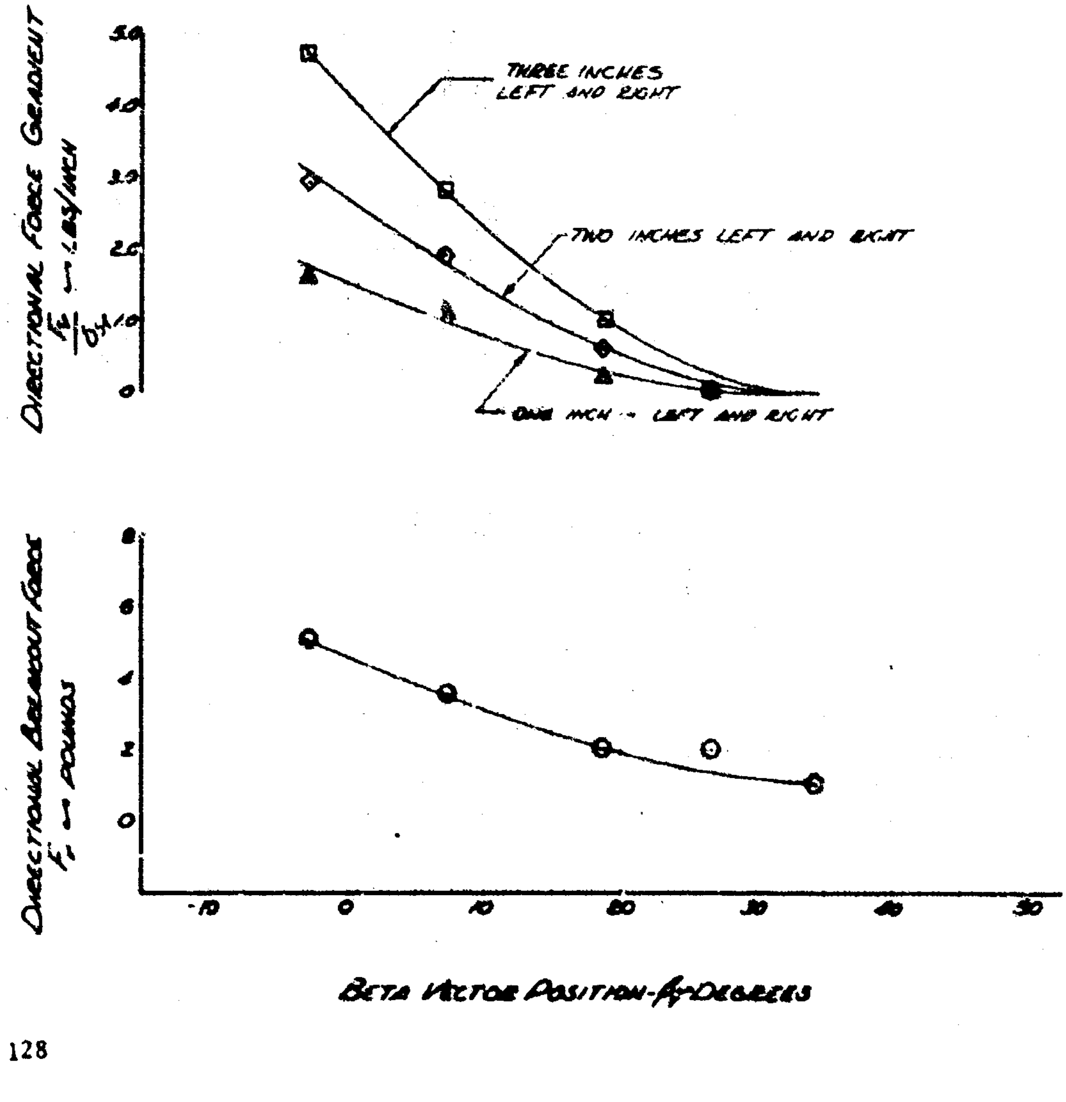


FIGURE No. 16
DIRECTIONAL PEDAL FORCE
XV-5A USA S/N 62-4505
FAN MODE
BETA VECTOR POSITION = 2.7 DEG FWD.

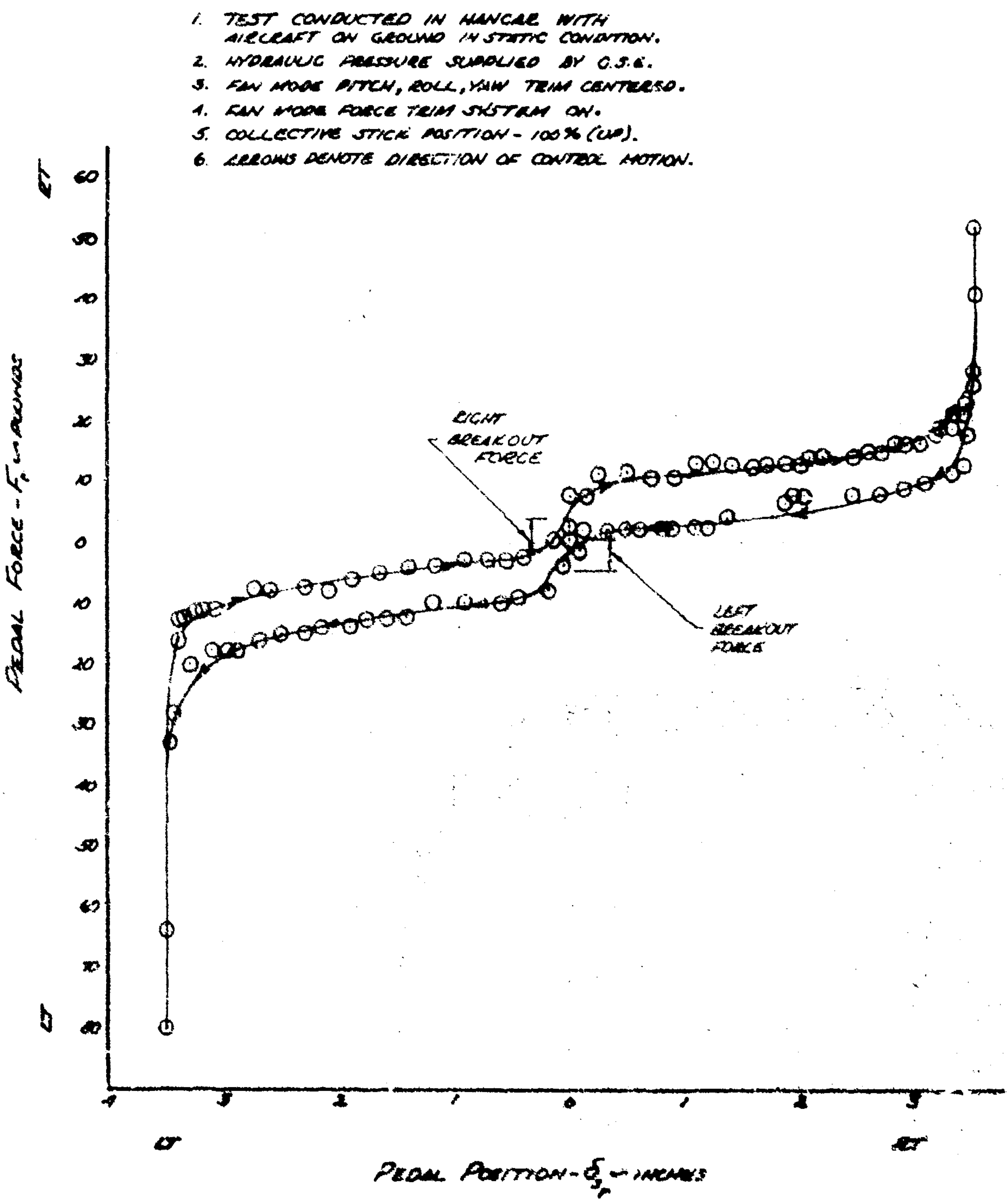


FIGURE NO. 17
DIRECTIONAL PEDAL FORCE
XV-5A USA S/N 62-4505
FAN MODE
BETA VECTOR POSITION = 8.3 DEG. AFT.

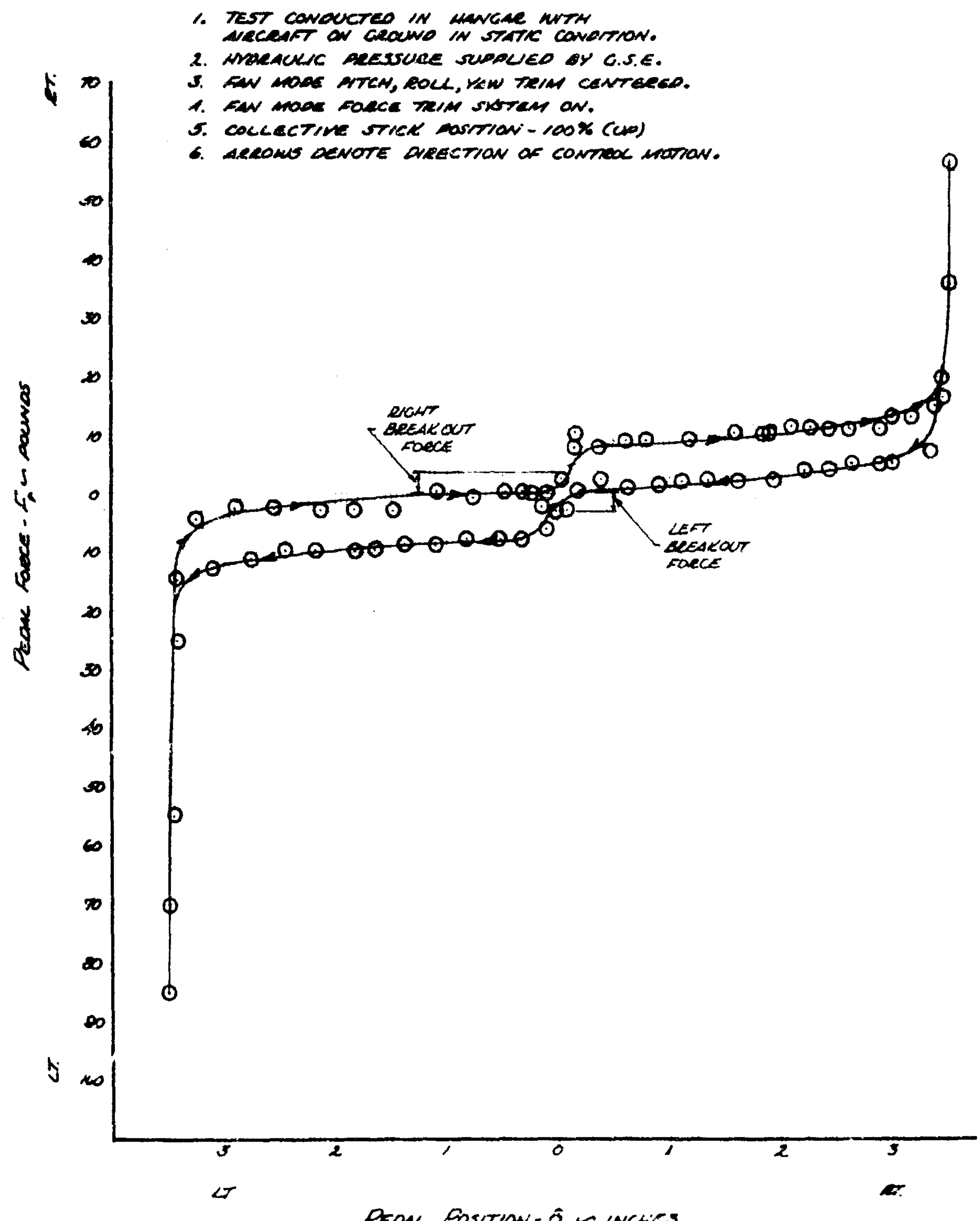


FIGURE No. 18
DIRECTIONAL PEDAL FORCE
XV-5A USA S/N 62-4505
FAN MODE
BETA VECTOR POSITION = 18.9 DEG. AFT

1. TEST CONDUCTED IN HANGAR WITH AIRCRAFT ON GROUND IN STATIC CONDITION.
2. HYDRAULIC PRESSURE SUPPLIED BY G.S.E.
3. FAN MODE PITCH, ROLL, YAW TRIM CENTERED.
4. FAN MODE FORCE TRIM SYSTEM ON.
5. COLLECTIVE STICK POSITION - 100 % (UP)
6. ARROWS DENOTE DIRECTION OF CONTROL MOTION.

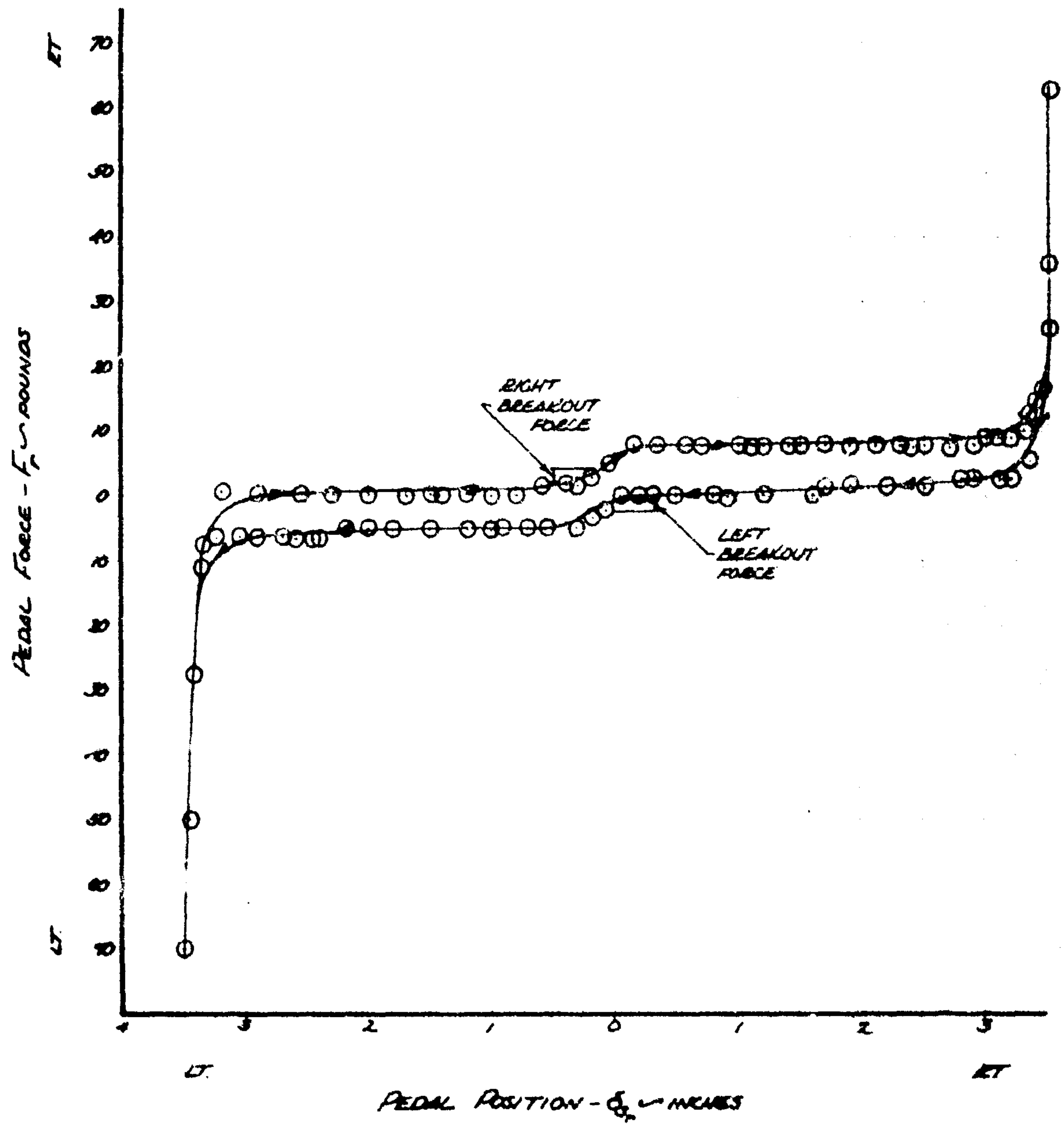


FIGURE No. 19
DIRECTIONAL PEDAL FORCE
XV-5A USA S/N 62-4505
FAN MODE
BETA VECTOR POSITION = 26.8 DEG AFT

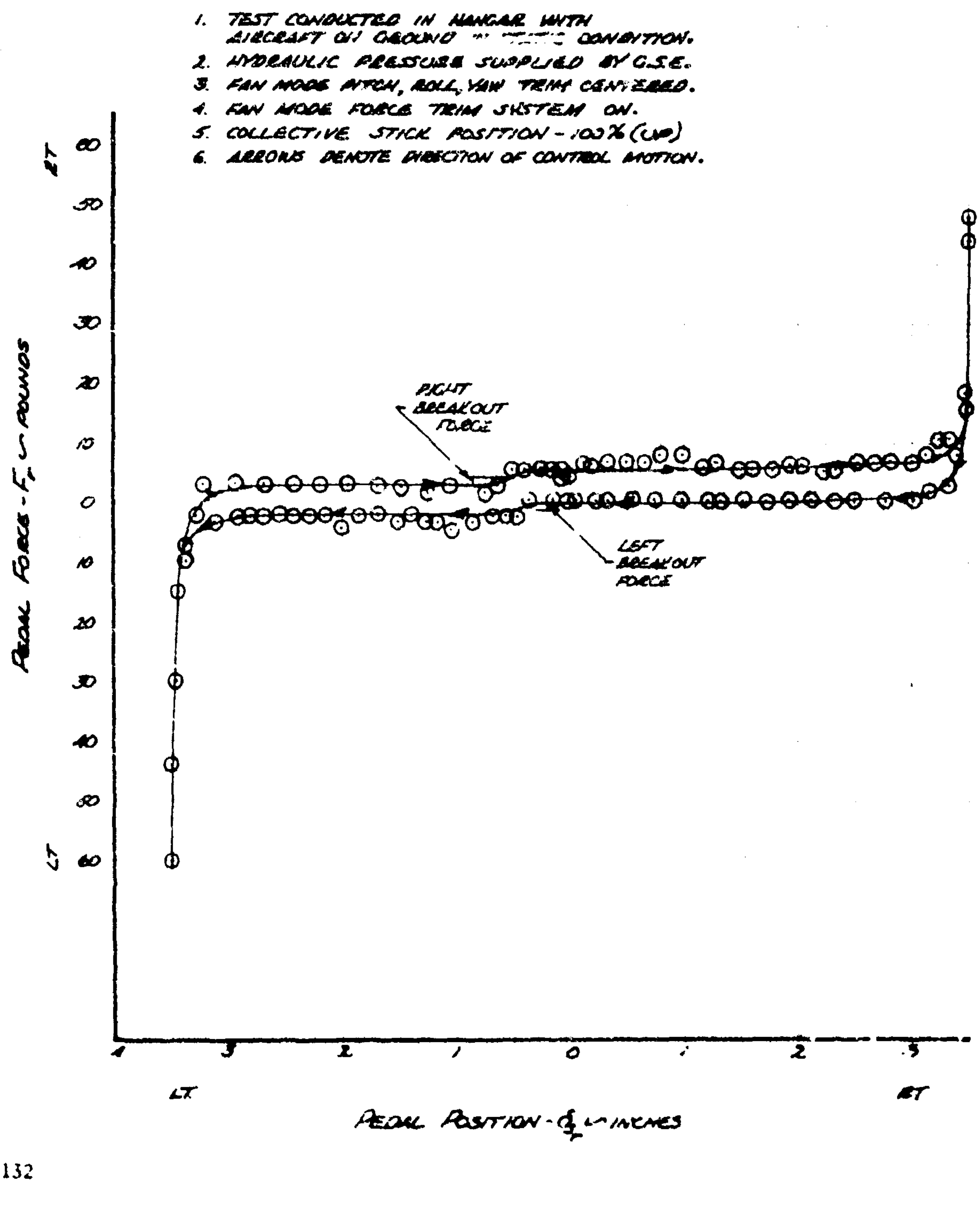


FIGURE No. 20
DIRECTIONAL PEDAL FORCE
XV-5A USA S/N 62-4505
FAN MODE
BETA VECTOR POSITION = 34.6 DEG. AFT.

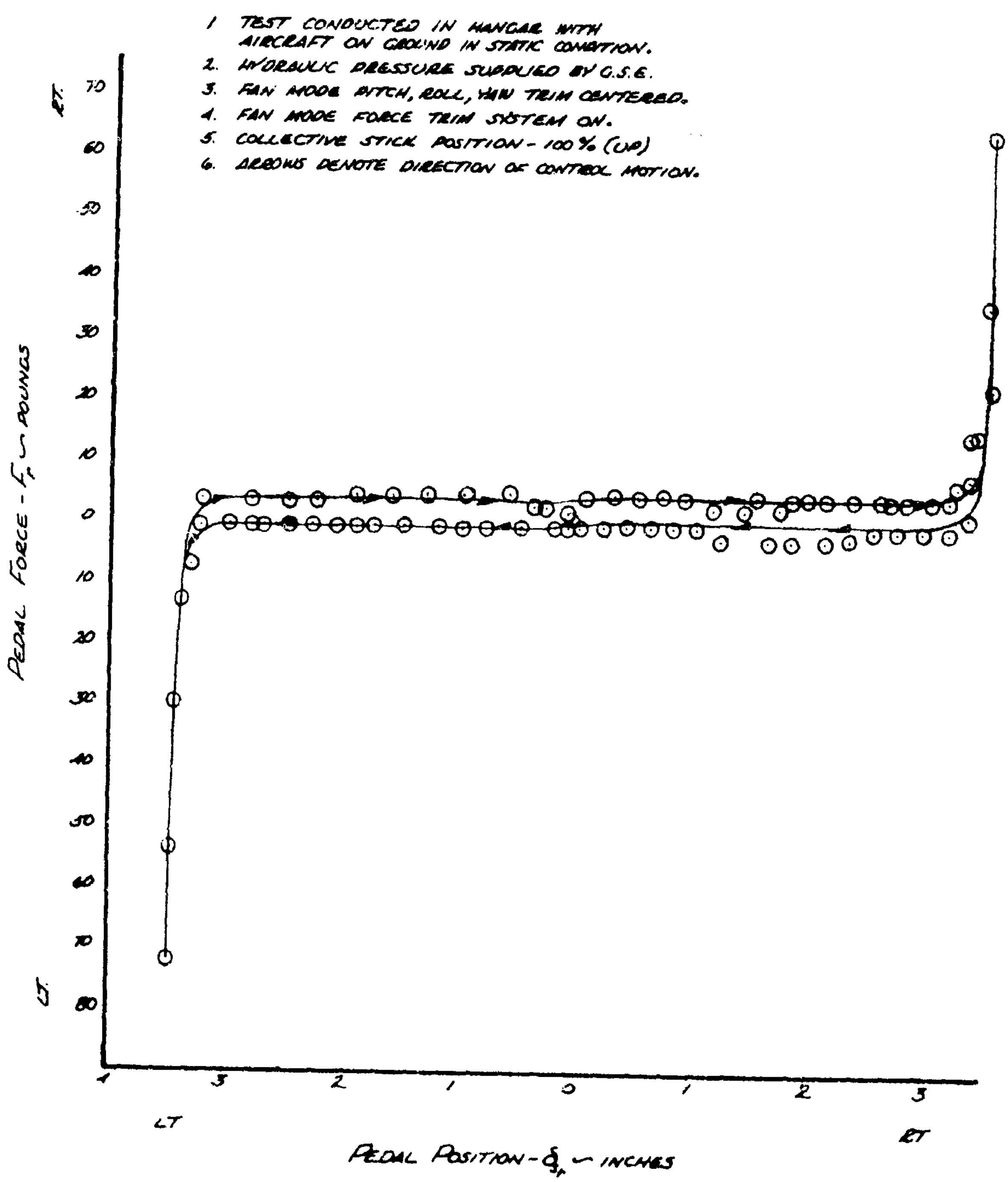


FIGURE No. 21
DIRECTIONAL PEDAL FORCE
XV-5A USA S/N 62-4505
JET MODE, PRE-CONVERSION
BETA VECTOR POSITION = 38.7 DEG AFT.

1. TEST CONDUCTED IN HANGAR WITH AIRCRAFT ON GROUND IN STATIC CONDITION.
2. HYDRAULIC PRESSURE SUPPLIED BY G.S.E.
3. ARROWS DENOTE DIRECTION OF CONTROL MOTION.

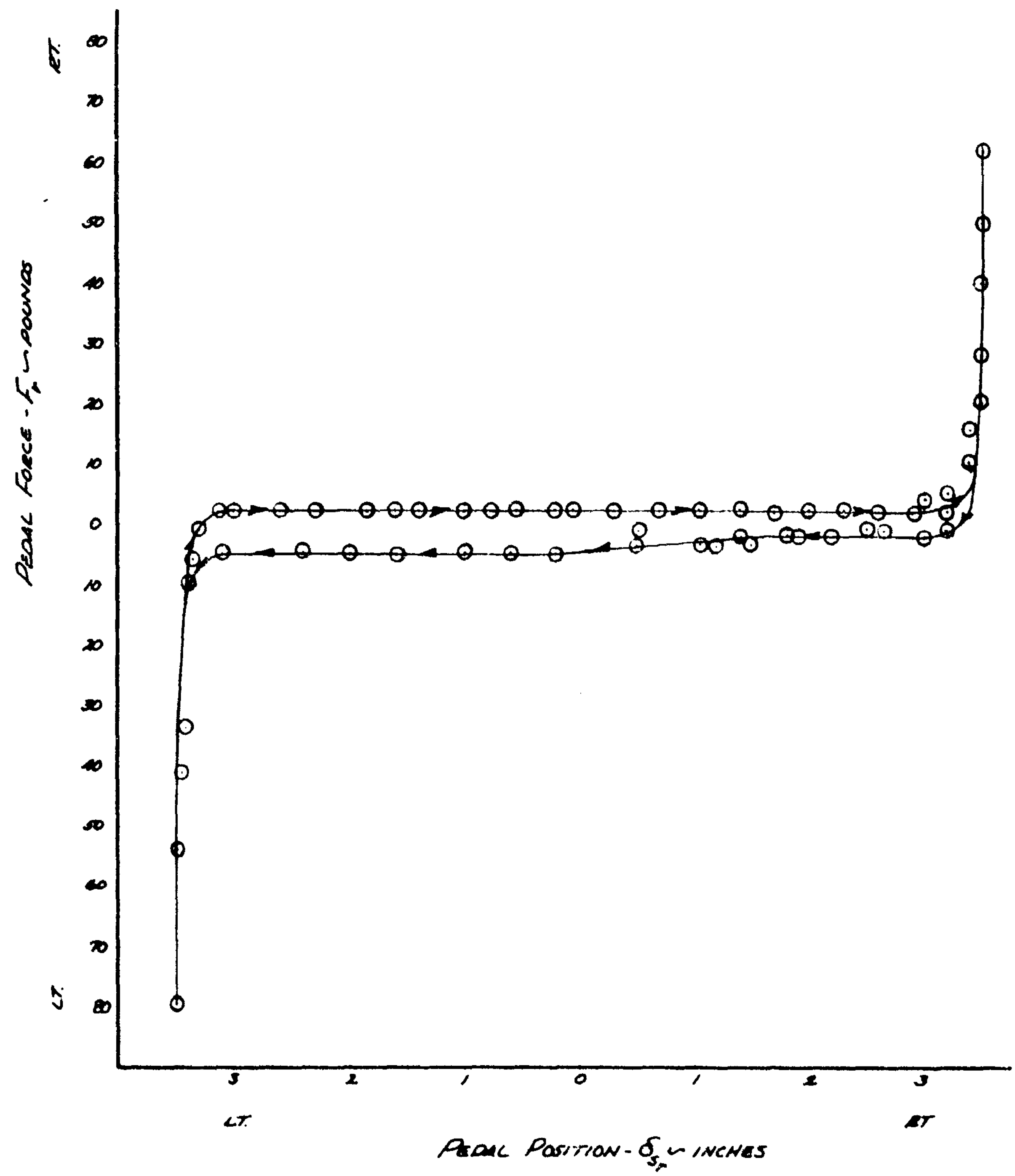


FIGURE No. 22
PITCH FAN DOOR POSITION
VARIATION WITH COLLECTIVE STICK POSITION
XV-5A USA ℅ 62-4505

SYM	BETA VECTOR POSITION	CONFIGURATION
☆	10.5 DEG. FWD	FAN MODE
○	2.7 DEG FWD	FAN MODE
△	8.6 DEG AFT	FAN MODE
◇	18.2 DEG AFT	FAN MODE
⬡	26.5 DEG AFT	FAN MODE

1. TEST CONDUCTED IN HANGAR WITH AIRCRAFT ON GROUND IN STATIC CONDITION.
2. HYDRAULIC PRESSURE SUPPLIED BY G.S.E.
3. FAN MODE PITCH, ROLL, YAW TRIM CENTERED.
4. COLLECTIVE STICK POSITION AT 100% = FULL UP

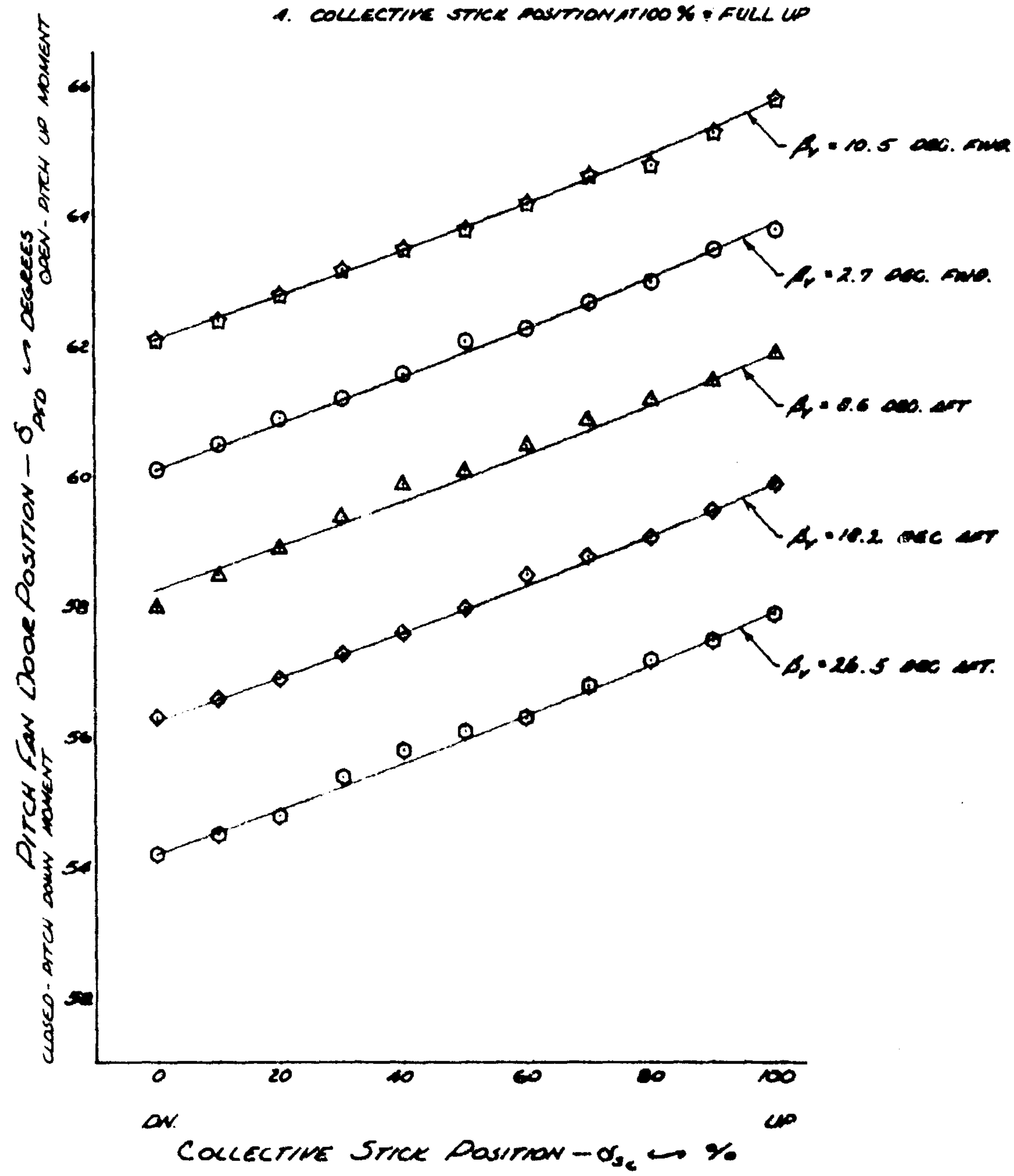


FIGURE No. 23
PITCH FAN DOOR POSITION
VARIATION WITH COLLECTIVE STICK POSITION
XV-5A USA S/N 62-4505

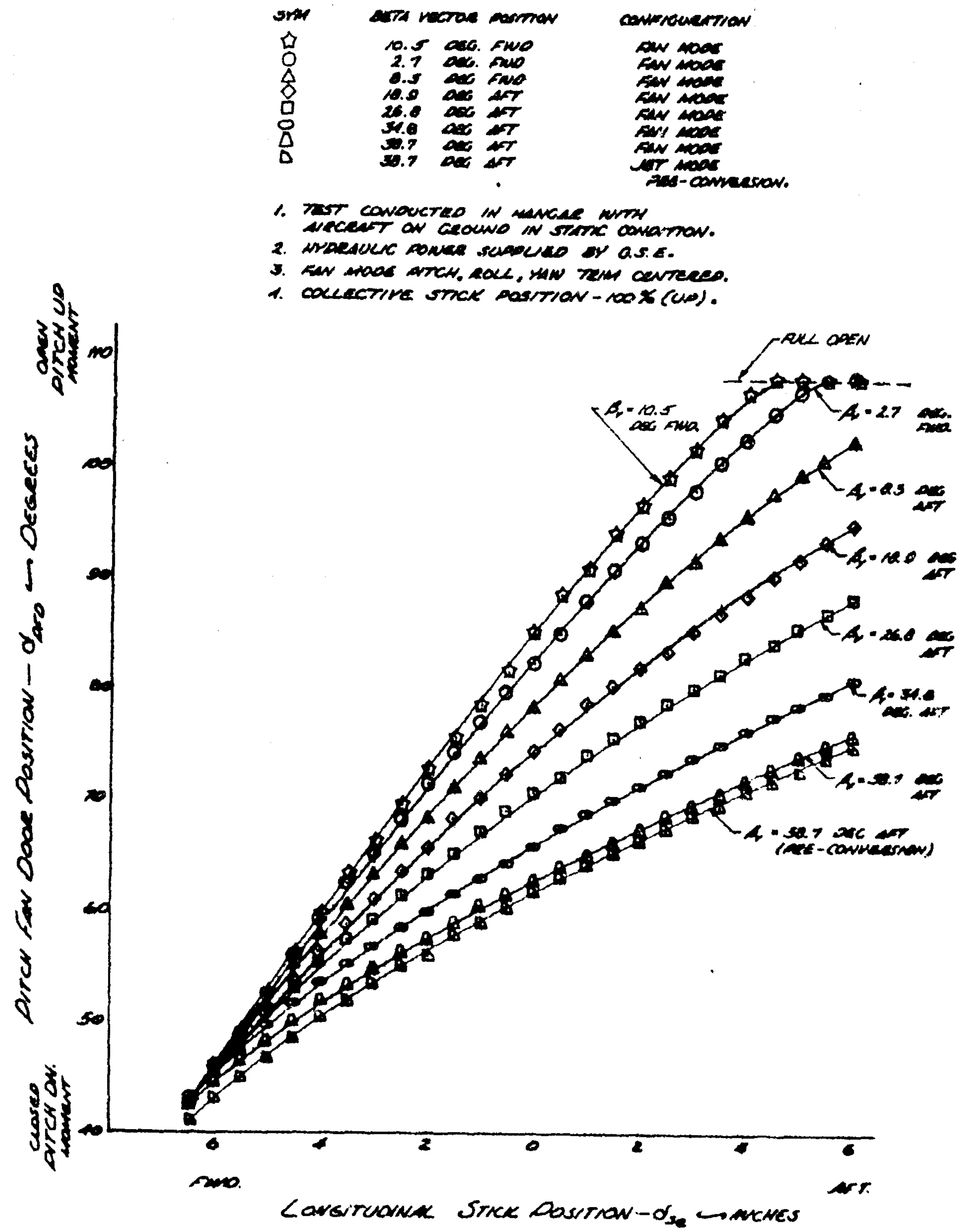


FIGURE NO. 24
ELEVATOR SURFACE POSITION VARIATION
WITH LONGITUDINAL STICK POSITION
XV-5A USA S/N 62-4505

SYM	HOR. STABILIZER POSITION
△	5 DEG. T.E.U.
□	0
○	20 DEG T.E.D.

1. TESTS CONDUCTED IN HANGER WITH AIRCRAFT ON GROUND IN STATIC CONDITION.
2. HYDRAULIC PRESSURE SUPPLIED BY G.S.E.

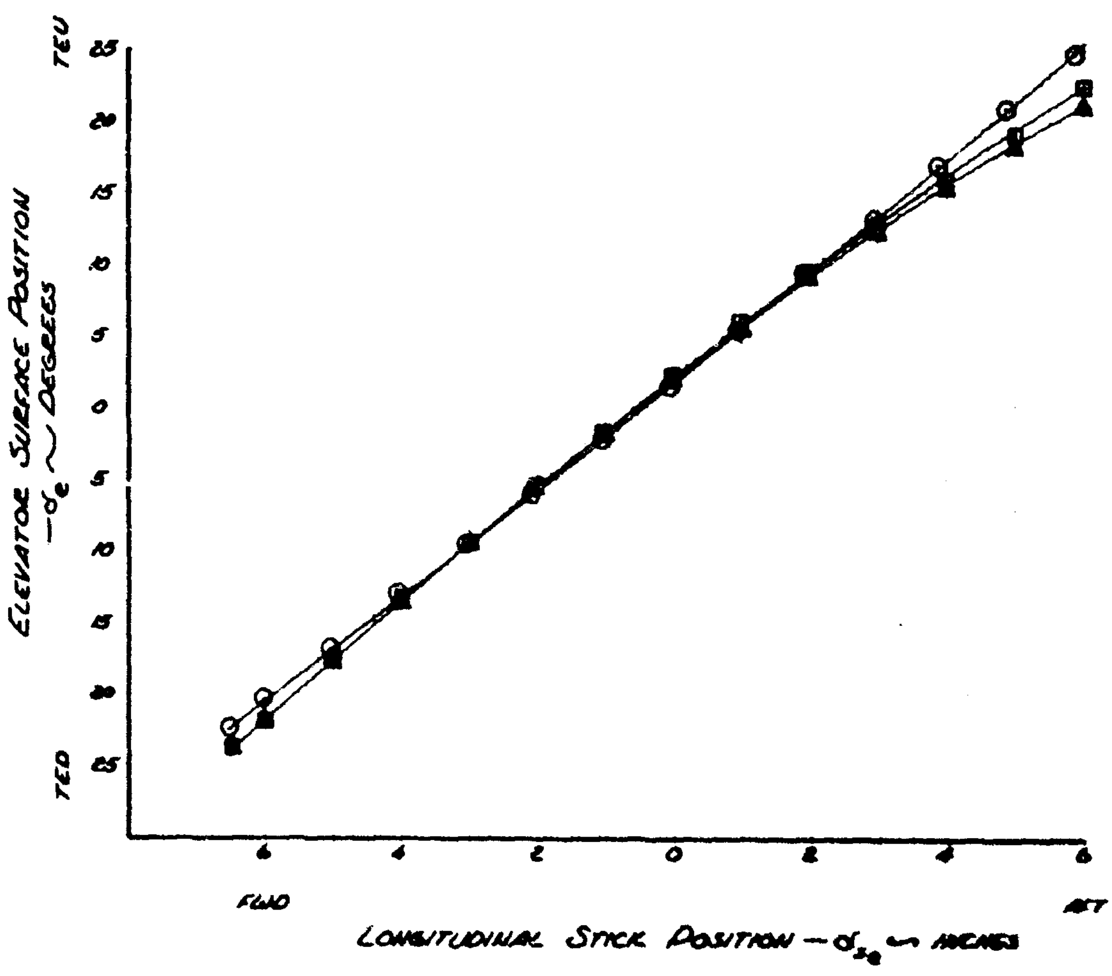


FIGURE No. 25

DIFFERENTIAL BETA STAGGER VARIATION WITH LATERAL STICK POSITION

XV-5A USA S/N 62-4505

SYM	BETA VECTOR POSITION	CONFIGURATION
☆	10.5 DEG FWD	FAN MODE
○	2.7 DEG FWD	FAN MODE
△	8.3 DEG AFT	FAN MODE
◇	18.9 DEG AFT	FAN MODE
□	26.8 DEG AFT	FAN MODE
⬭	34.6 DEG AFT	FAN MODE

1. TEST CONDUCTED IN HANGAR WITH AIRCRAFT ON GROUND IN STATIC CONDITION.
2. HYDRAULIC PRESSURE SUPPLIED BY G.S.E.
3. FAN MODE PITCH, ROLL, YAW TRIM CENTERED.
4. COLLECTIVE STICK POSITION = 100% (UP)

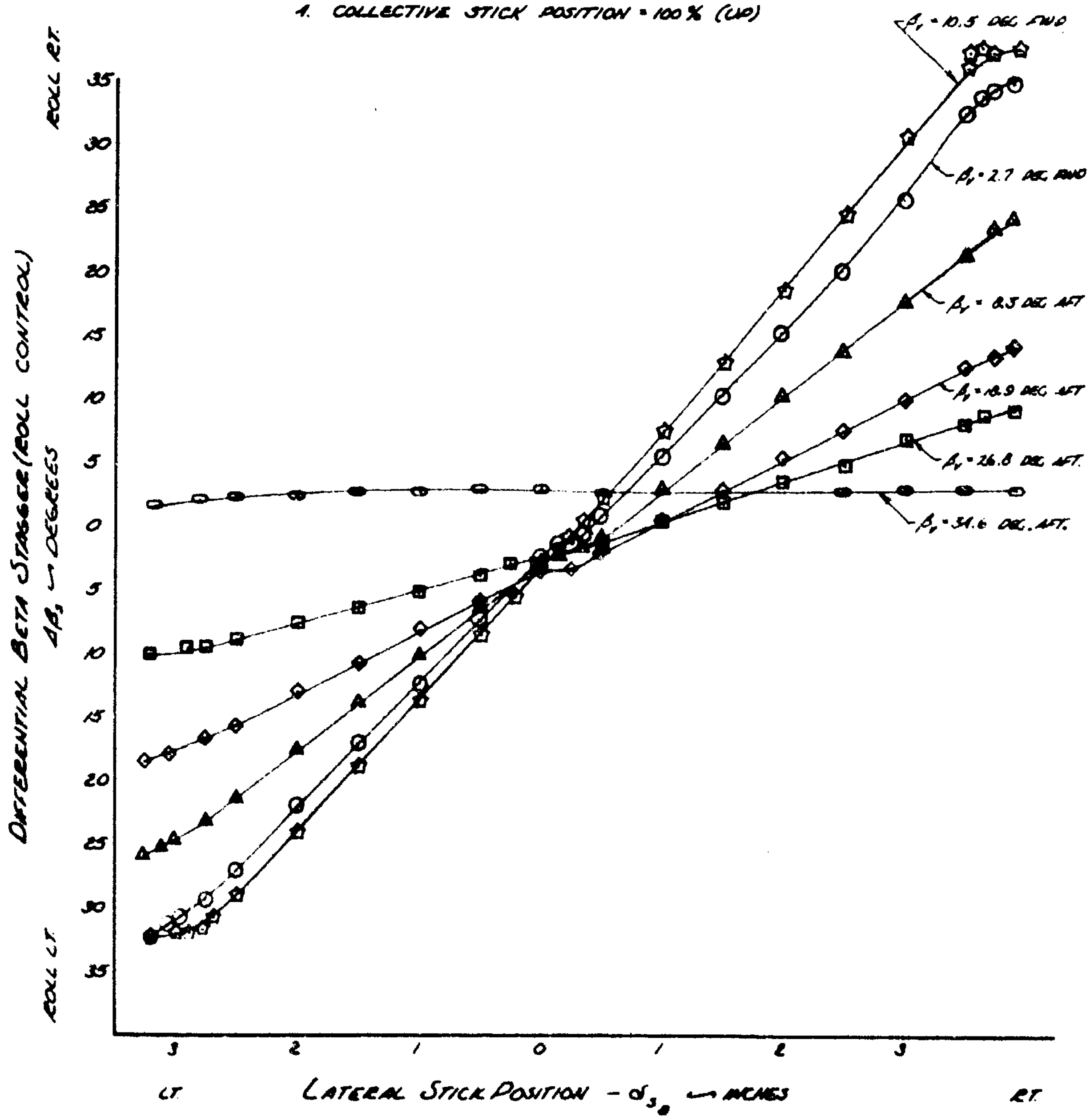


FIGURE No. 26

AILERON SURFACE POSITION VARIATION WITH LATERAL STICK POSITION

XV-5A USA S/N 62-4505

JET MODE

1. TEST CONDUCTED IN HANGER WITH AIRCRAFT ON GROUND IN STATIC CONDITION
2. FLAP POSITION = 45 DEGREES (FULL DOWN)
3. HYDRAULIC POWER SUPPLIED BY G.S.E.

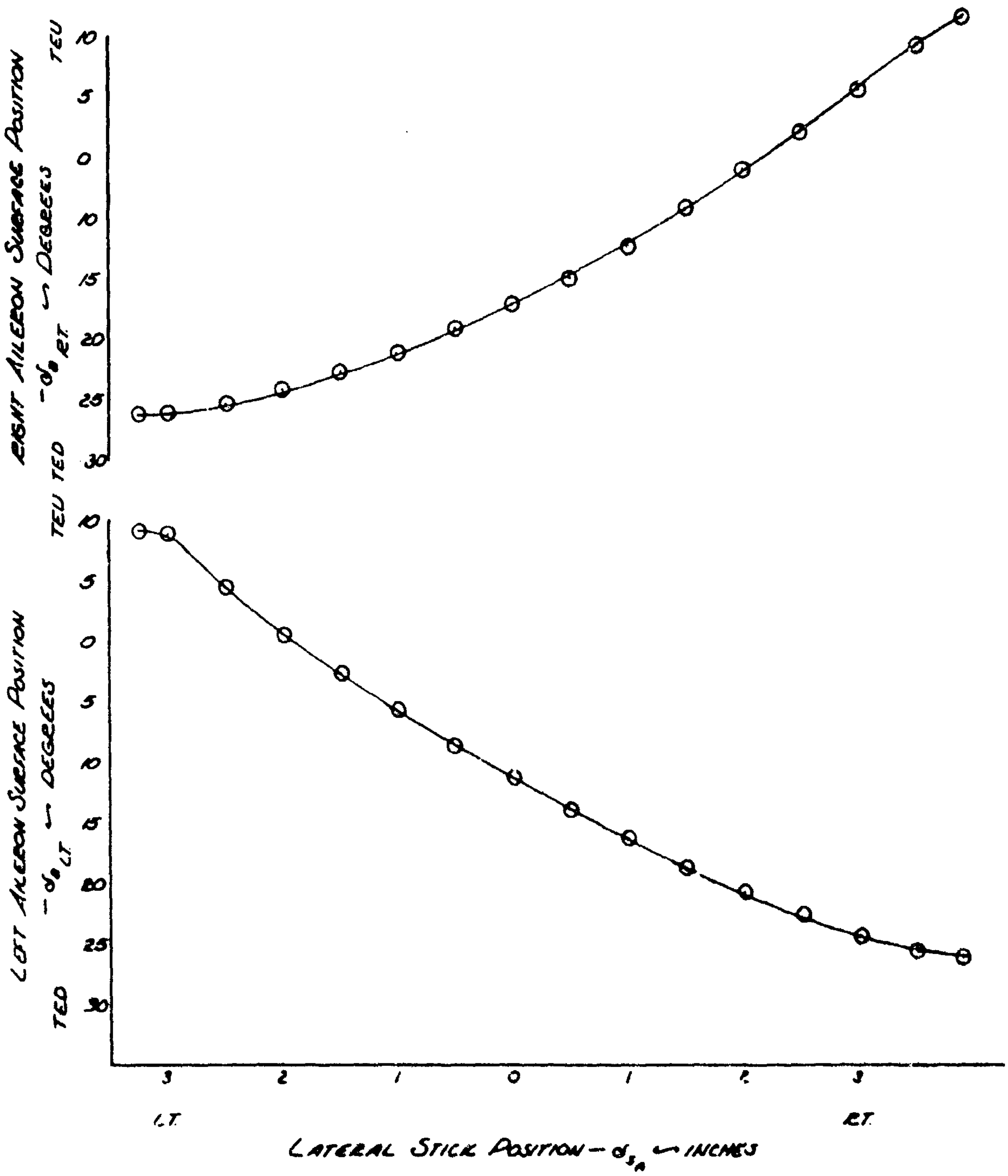


FIGURE NO. 27
AILERON SURFACE POSITION VARIATION WITH LATERAL STICK POSITION
XV-5A USA S/N 62-4505
JET MODE

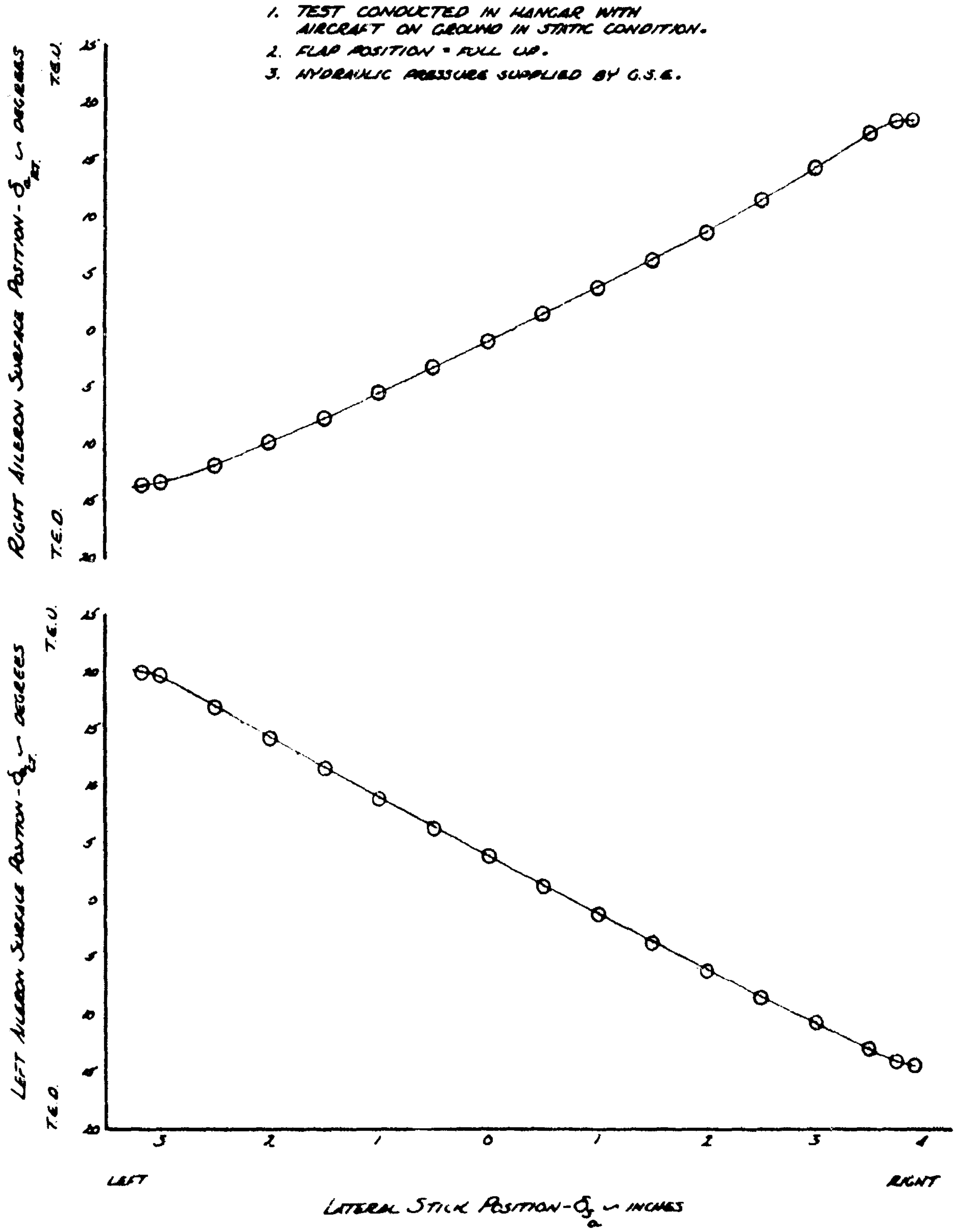


FIGURE No. 28
DIFFERENTIAL BETA VECTOR VARIATION
WITH RUDDER PEDAL POSITION

XV-5A USA S/N 62-4505

FAN MODE

SYM.	BETA VECTOR POSITION
☆	10.5 DEG FWD.
	2.7 DEG FWD.
△	8.3 DEG AFT
◇	18.9 DEG AFT.
□	26.8 DEG AFT.
O	34.6 DEG AFT.

1. TEST CONDUCTED IN HANGER WITH AIRCRAFT ON GROUND IN STATIC CONDITION.
2. HYDRAULIC PRESSURE SUPPLIED BY G.S.E.
3. FAN MODE PITCH, ROLL, YAW TRIM CENTERED.
4. COLLECTIVE STICK POSITION - 100% (UP)

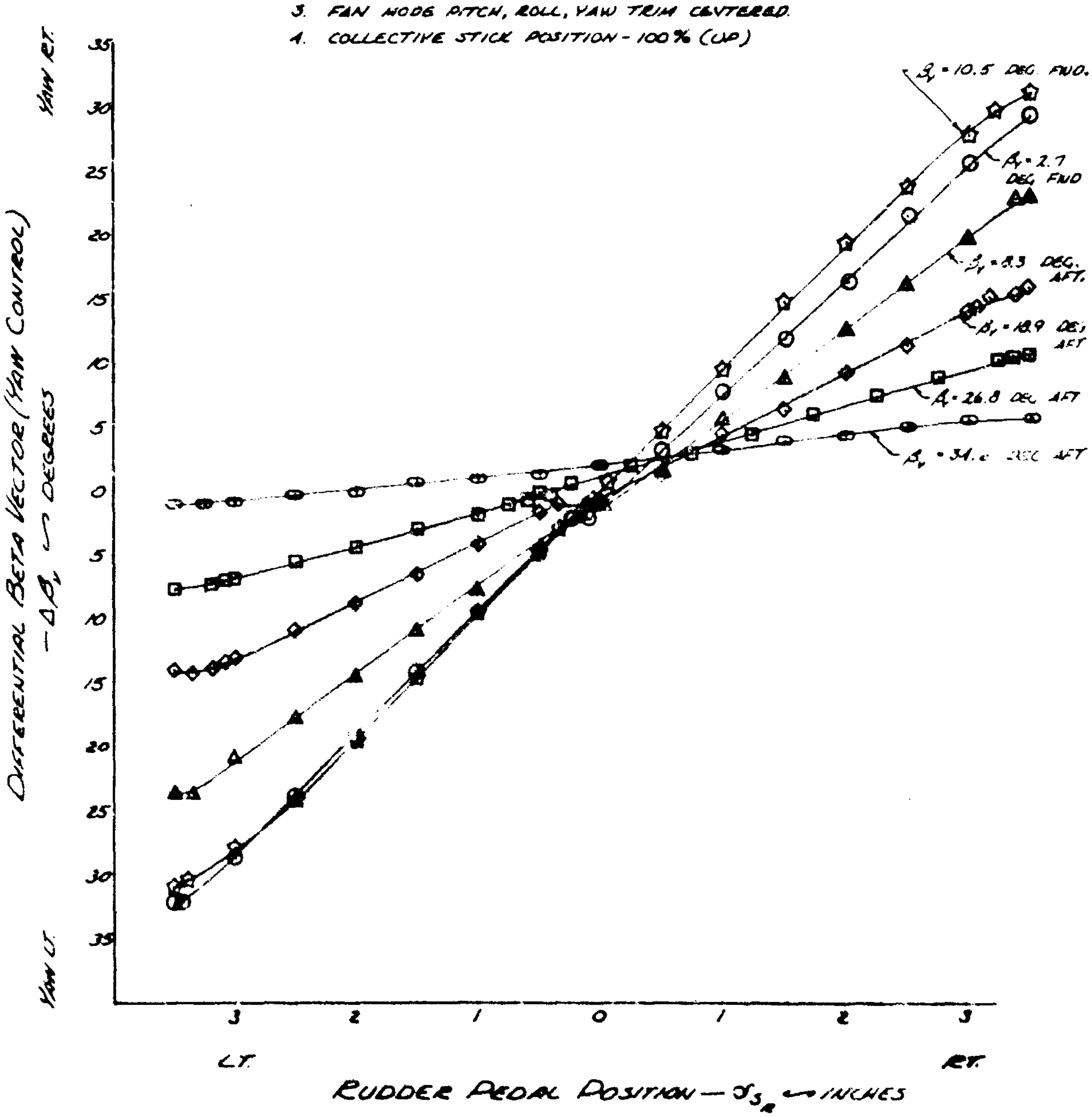


FIGURE No. 29

DIFFERENTIAL BETA STAGGER VARIATION
WITH RUDDER PEDAL POSITION

XV-5A USA S/N 62-4505

FAN MODE

SYM	BETA VECTOR POSITION
☆	10.5 DEG FWD
○	2.7 DEG FWD
△	8.3 DEG AFT
◇	18.9 DEG AFT
□	26.8 DEG AFT
⬭	34.6 DEG AFT

1. TEST CONDUCTED IN HANGAR WITH AIRCRAFT ON GROUND IN STATIC CONDITION.
2. HYDRAULIC PRESSURE SUPPLIED BY G.S.E.
3. FAN MODE PITCH, ROLL, YAW TRIM CENTERED
4. COLLECTIVE STICK POSITION - 100% (UP)

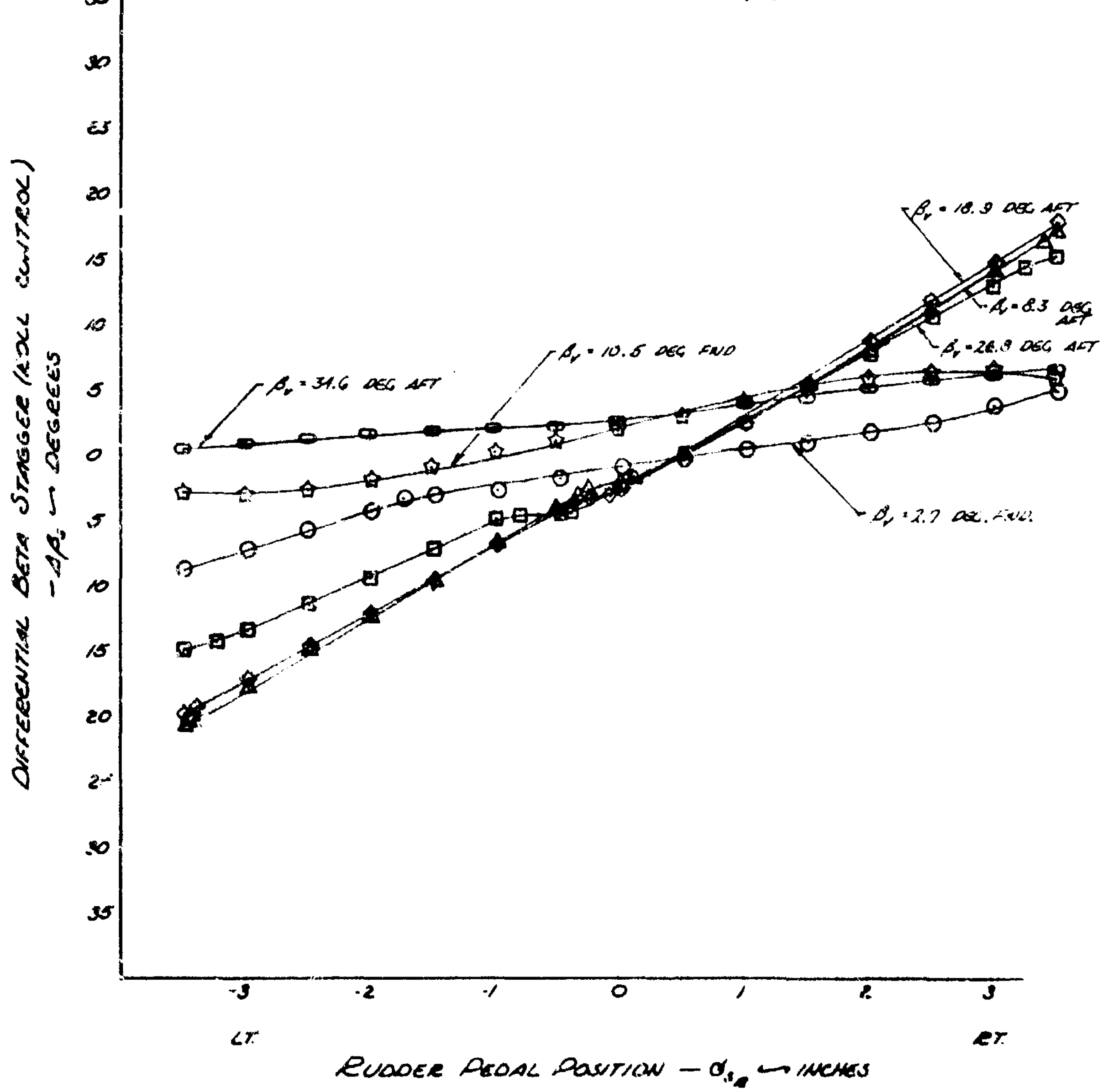


FIGURE No. 30
RUDDER SURFACE POSITION VARIATION
WITH RUDDER PEDAL POSITION
XV-5A USA S/N 62-4505

1. TEST CONDUCTED IN HANGAR WITH AIRCRAFT ON GROUND IN STATIC CONDITION.
2. HYDRAULIC PRESSURE SUPPLIED BY G.S.E.

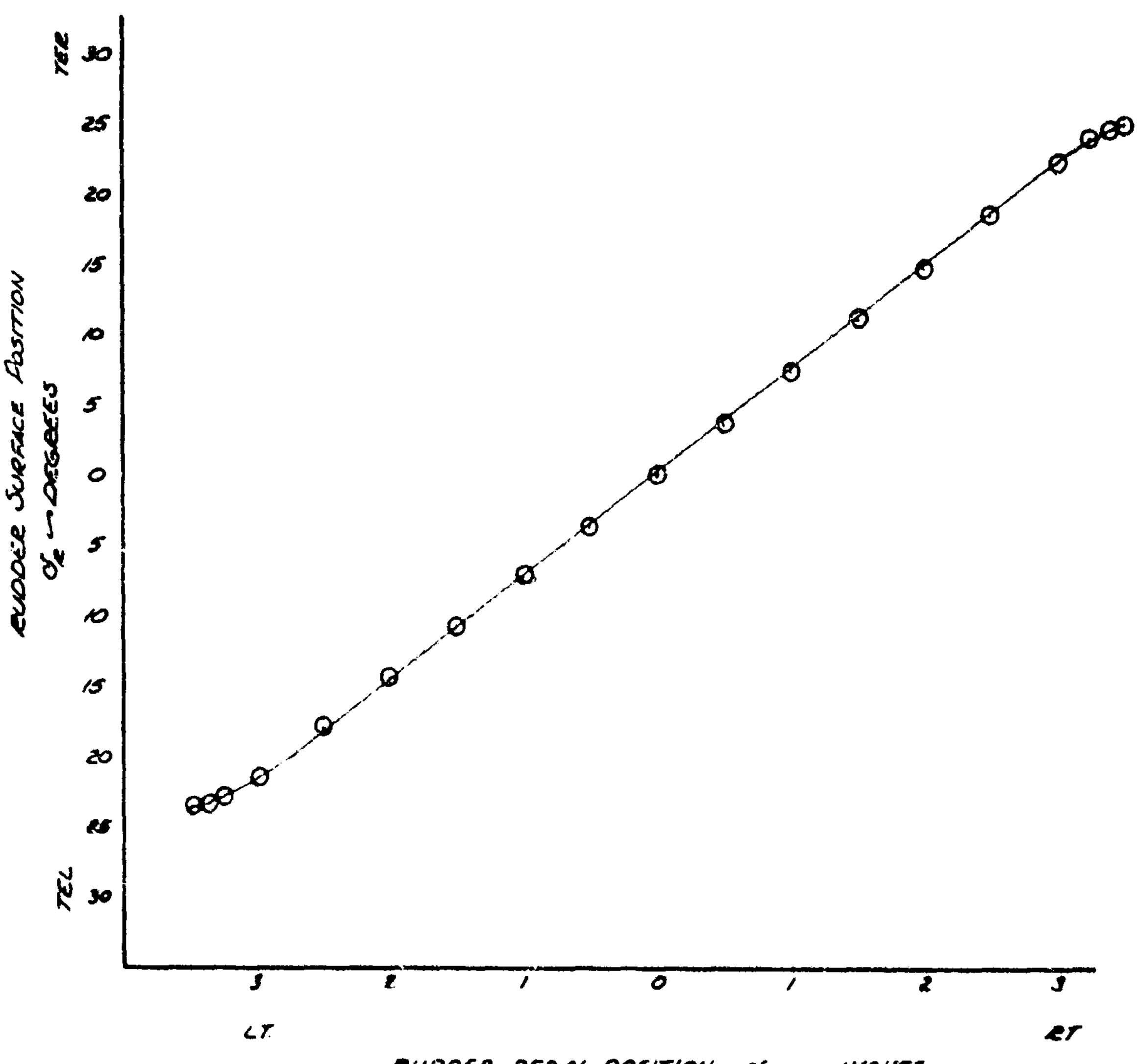


FIGURE NO. 31

WING FAN STAGGER VARIATION WITH COLLECTIVE STICK POSITION

XV-5A USA S/N 62-4505

FAN MODE

SYM	BETA VECTOR POSITION
☆	10.5 DEG FWD
○	2.7 DEG FWD
△	8.6 DEG AFT
◇	18.6 DEG AFT
⬡	26.5 DEG AFT

1. TEST CONDUCTED IN HANGAR WITH AIRCRAFT ON GROUND IN STATIC CONDITION.
2. HYDRAULIC PRESSURE SUPPLIED BY G.S.E.
3. FAN MODE PITCH, ROLL, YAW TRIM CENTERED.
4. COLLECTIVE STICK POSITION - 100% (UP)

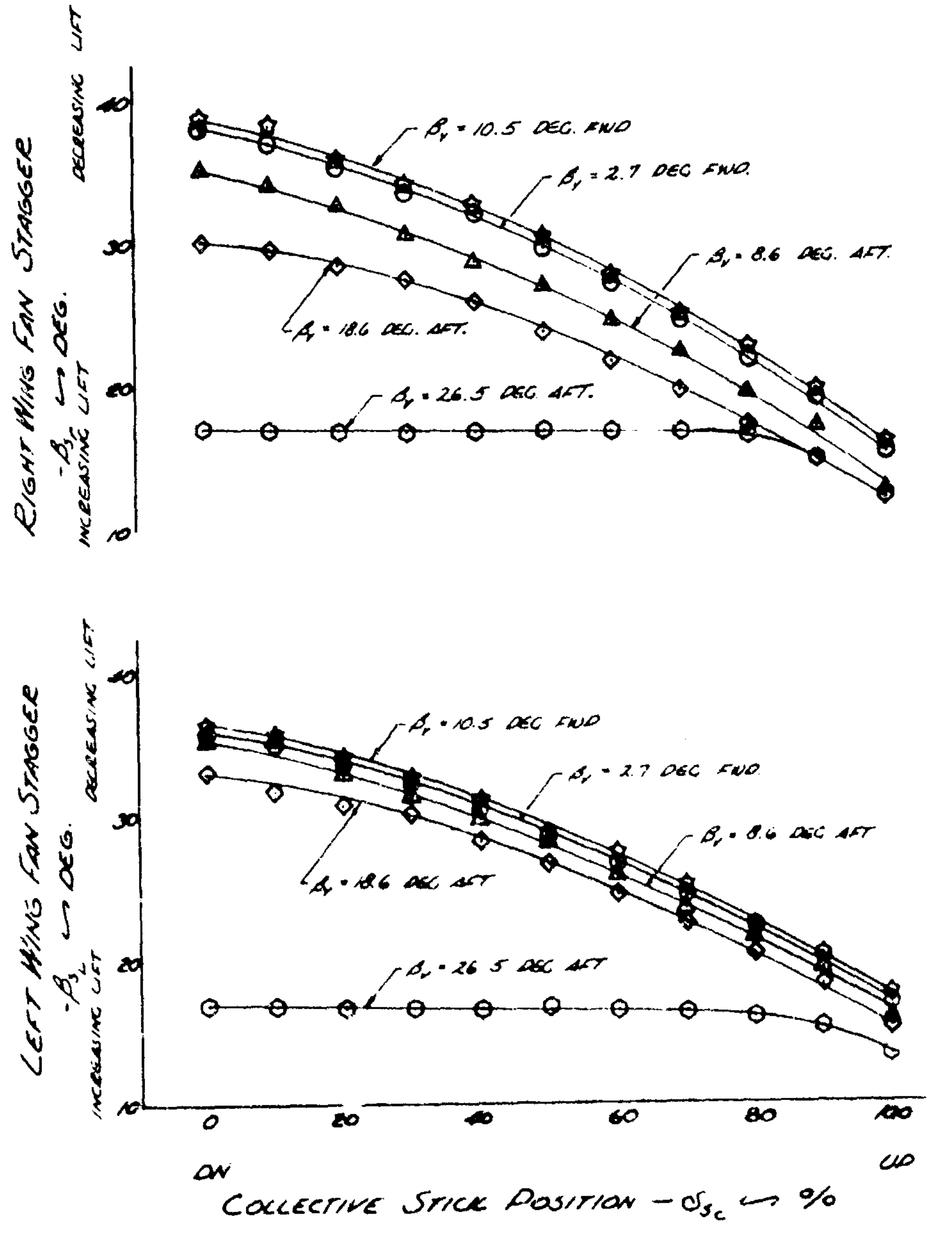
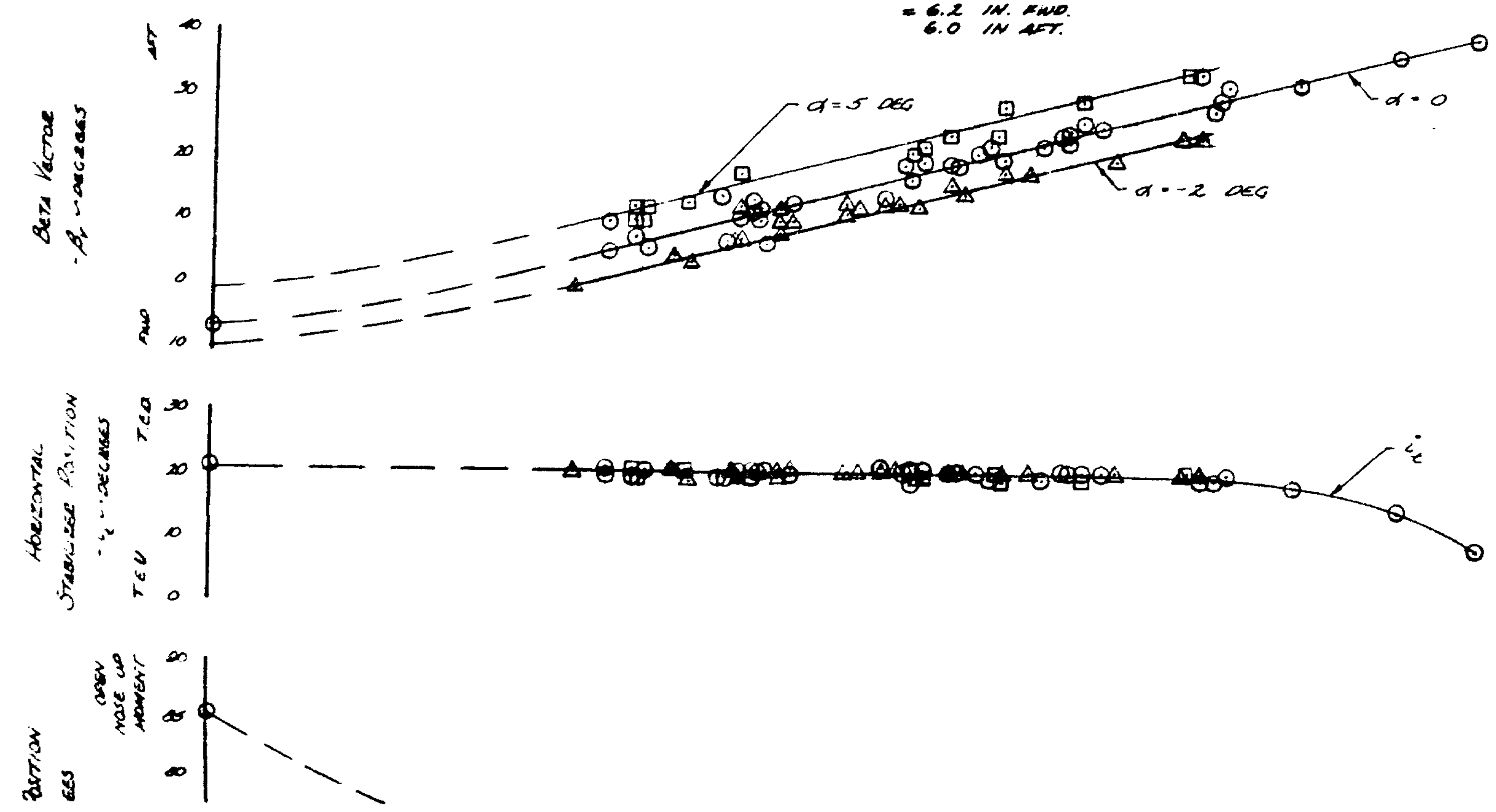
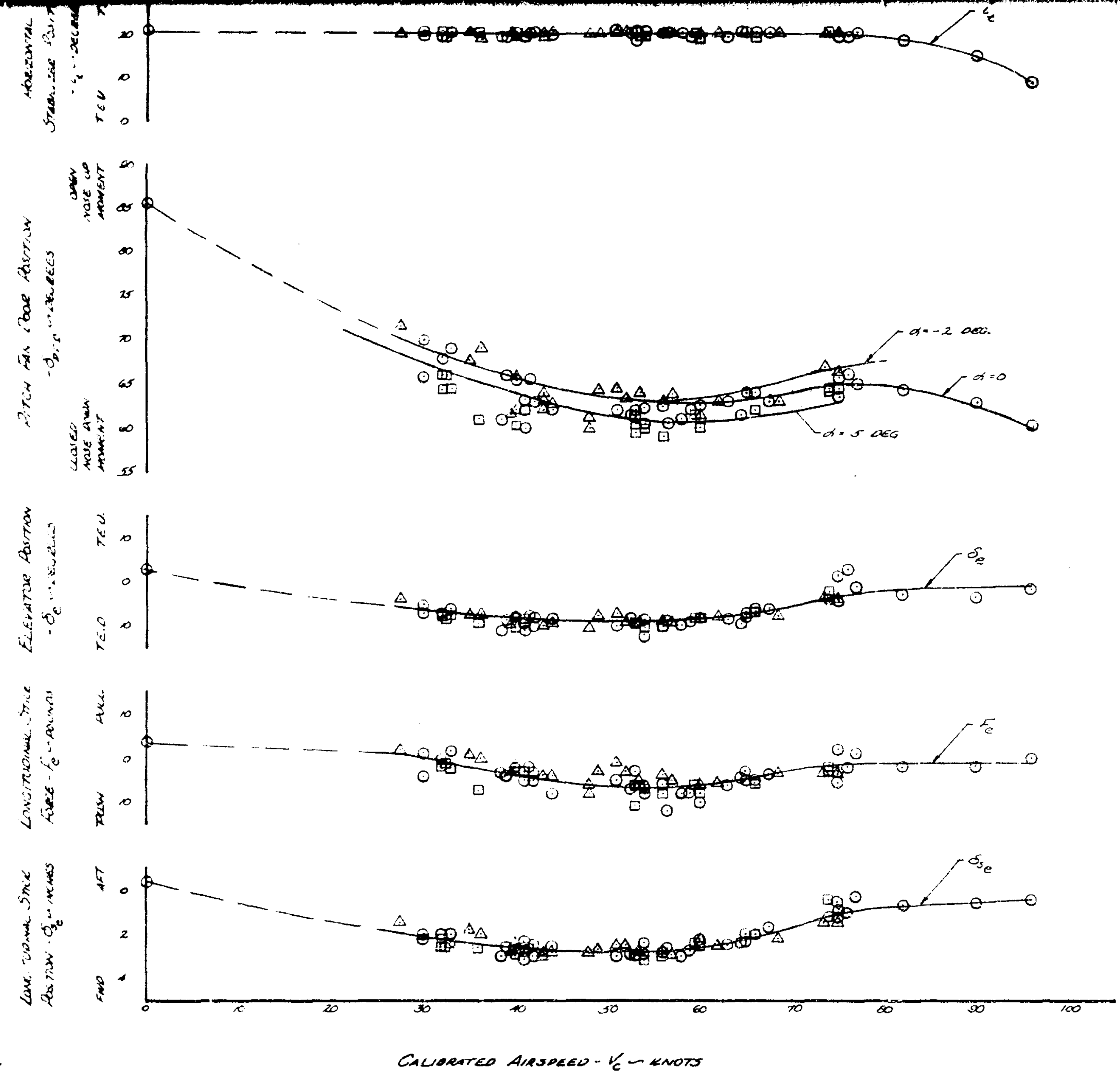


FIGURE No. 32
STATIC LONGITUDINAL TRIM STABILITY
XV-5A USA S/N 62-4505
FAN MODE

SYM	GEAR POS.	AVG ALT $-H_p$ ~ FT	ANGLE OF ATTACK ~ DEG.	AVG G.W. ~ LB	AVG C.G LOC ~ IN
△	DOWN	5750	-2	9810	241.5 (MID)
○	DOWN	5650	0	9730	241.4 (MID)
□	DOWN	5830	5	9670	241.1 (MID)

COLLECTIVE STICK POSITION = 100 % (UP)
LANDING GEAR FIXED IN THE DOWN POSITION
WITH HEAT SHIELD INSTALLED.
MAXIMUM LONGITUDINAL STICK DISPLACEMENT
= 6.2 IN. FWD.
6.0 IN AFT.




HORIZONTAL STABILIZER POSITION
PITCH FAN DOOR POSITION - δ_{PFD} ~ DEGREES
OPEN NOSE UP MOMENT
CLOSED NOSE DOWN MOMENT
α = -2 DEG.
α = 0
α = 5 DEG
ELEVATOR POSITION - δ_e
T.E.U.
T.E.D.
δ_e
LONGITUDINAL STICK FORCE - F_e ~ POUNDS
PULL
PUSH
F_e
LONGITUDINAL STICK POSITION - δ_{se} ~ INCHES
AFT
FWD
δ_{se}
CALIBRATED AIRSPEED - V_c ~ KNOTS

B

FIGURE No. 33

STATIC LONGITUDINAL TRIM STABILITY

XV-5A USA S/N 62-4505

FAN MODE

GEAR POSITION = UP
AVG PRESSURE ALT = 5110 FT.
ANGLE OF ATTACK = 0
SAS CONFIGURATION - OPTIMUM

COLLECTIVE STICK POS = 100 % (UP)
AVG GROSS WT = 11050 LB.
AVG C.G. LOCATION = 241.2 IN. (AMID)
MAX. LONG. STICK DISP. = 6.2 IN FWD.
6.0 IN AFT.

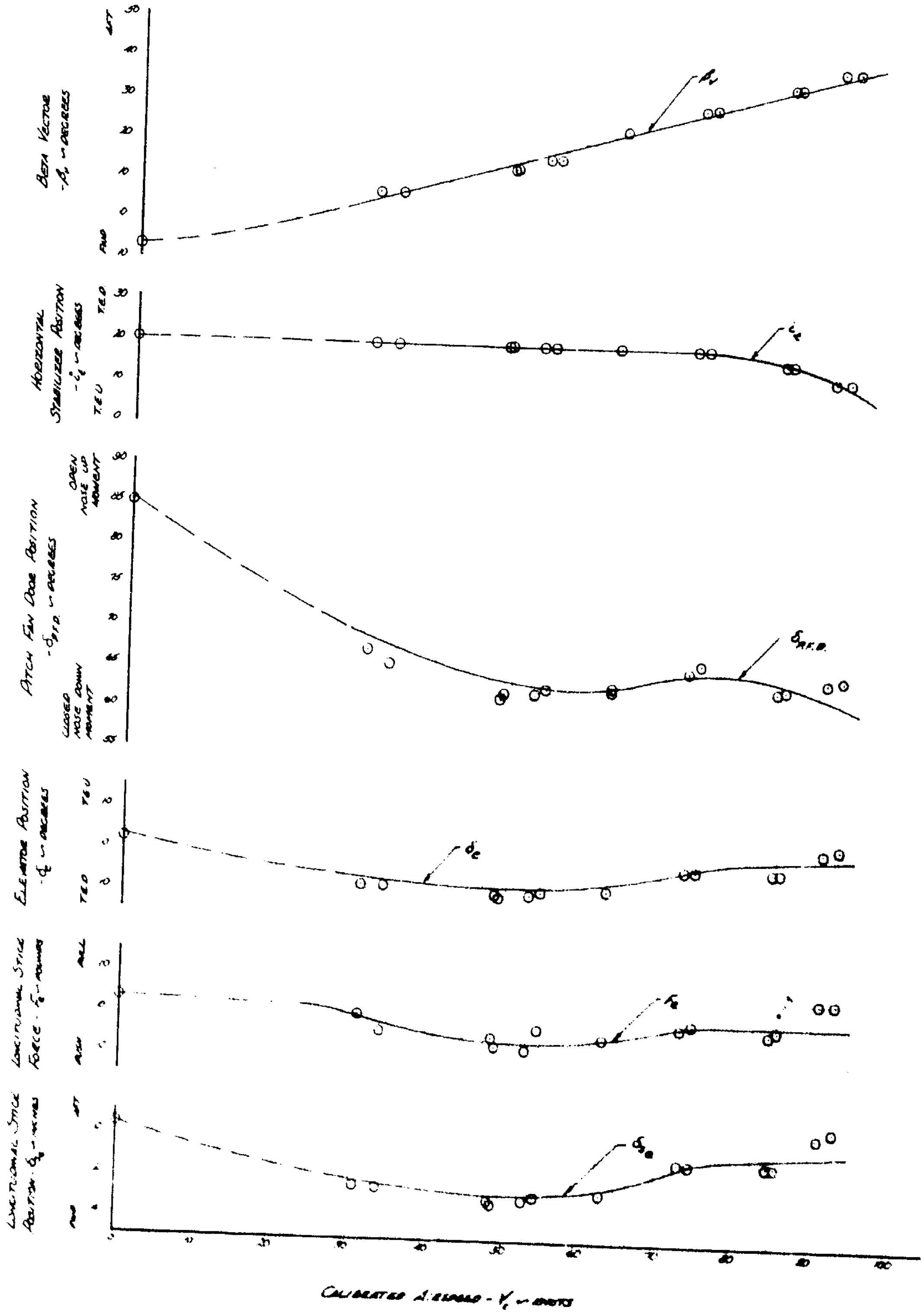
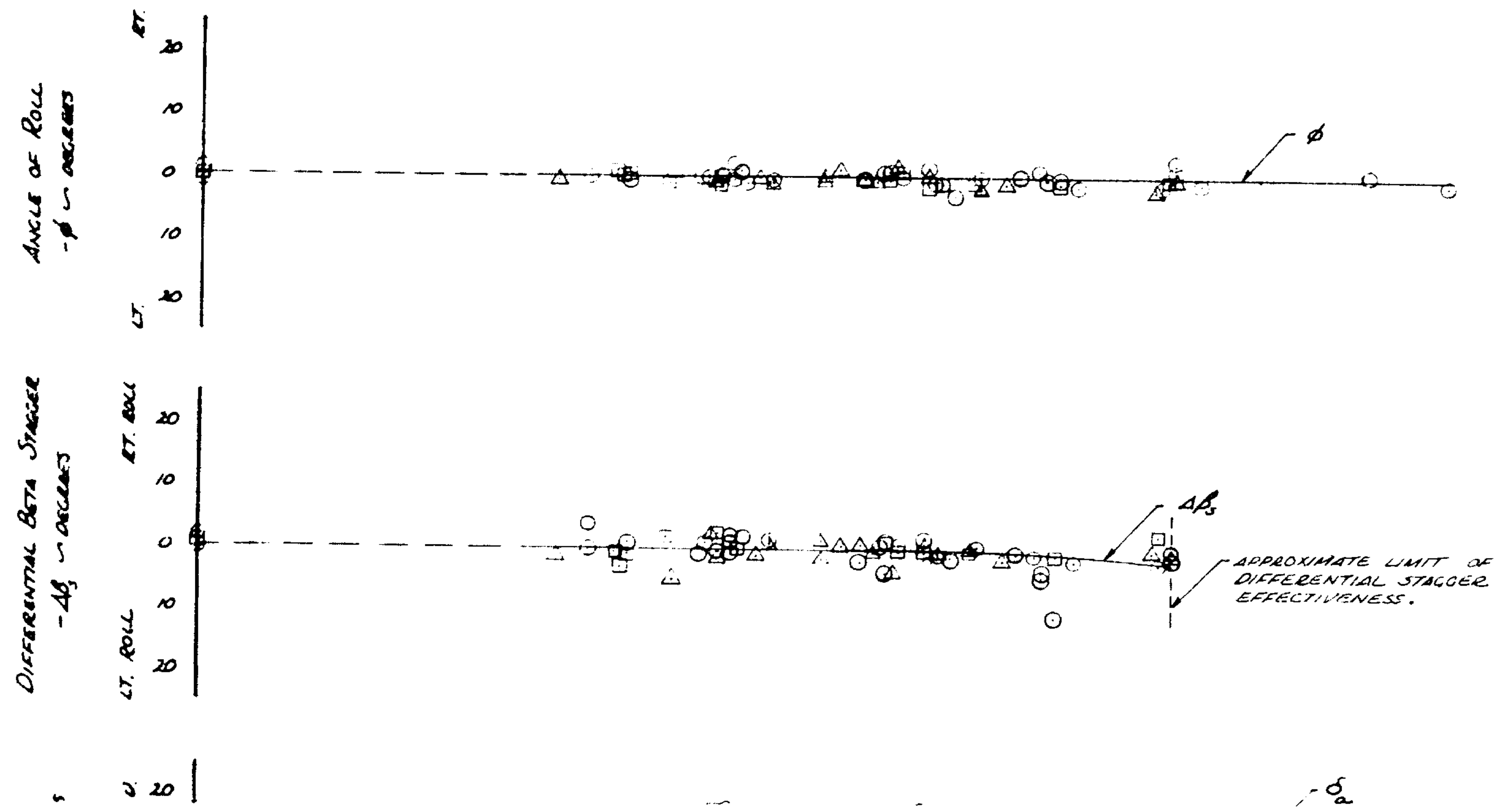
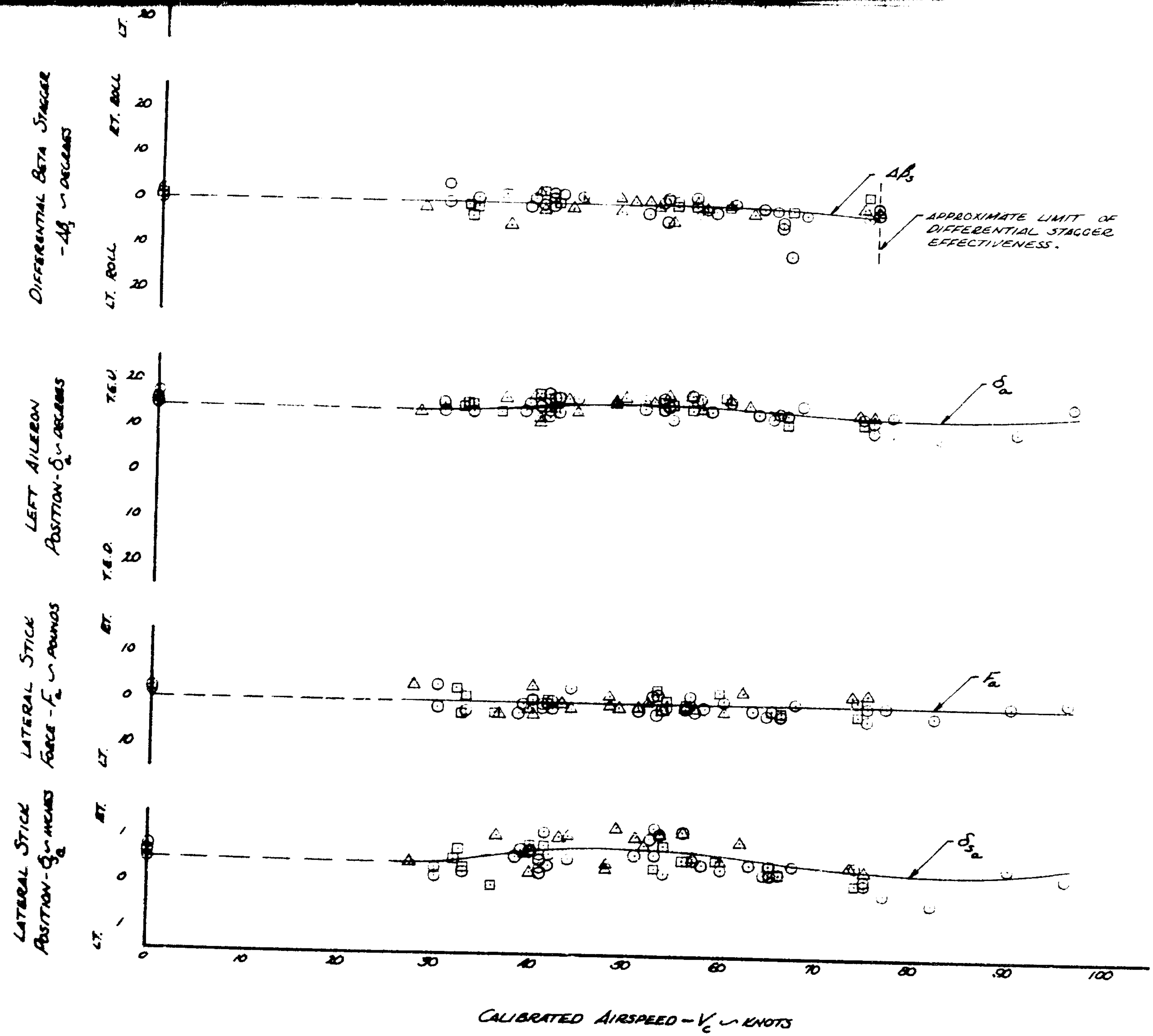


FIGURE NO. 34
STATIC LATERAL TRIM STABILITY
XV-5A USA S/N 62-4505
FAN MODE

SYM	GEAR POS	AVG ALT H_p ~ FT	ANGLE OF ATTACK ~ DEG	AVG G.W. ~ LB	AVG CG LOC ~ IN
△	ON	5750	-2	8810	241.5 (MID)
○	ON	5650	0	8730	241.4 (MID)
□	ON	5830	5	9670	241.1 (MID)

COLLECTIVE STICK POSITION = 100% (UP)
LANDING GEAR FIXED DOWN WITH THE HEAT SHIELD INSTALLED
MAXIMUM LONGITUDINAL STICK DISPLACEMENT = 6.2 IN FWD
6.0 IN AFT
MAXIMUM LATERAL STICK DISPLACEMENT = 3.9 INCHES RIGHT
3.2 INCHES LEFT



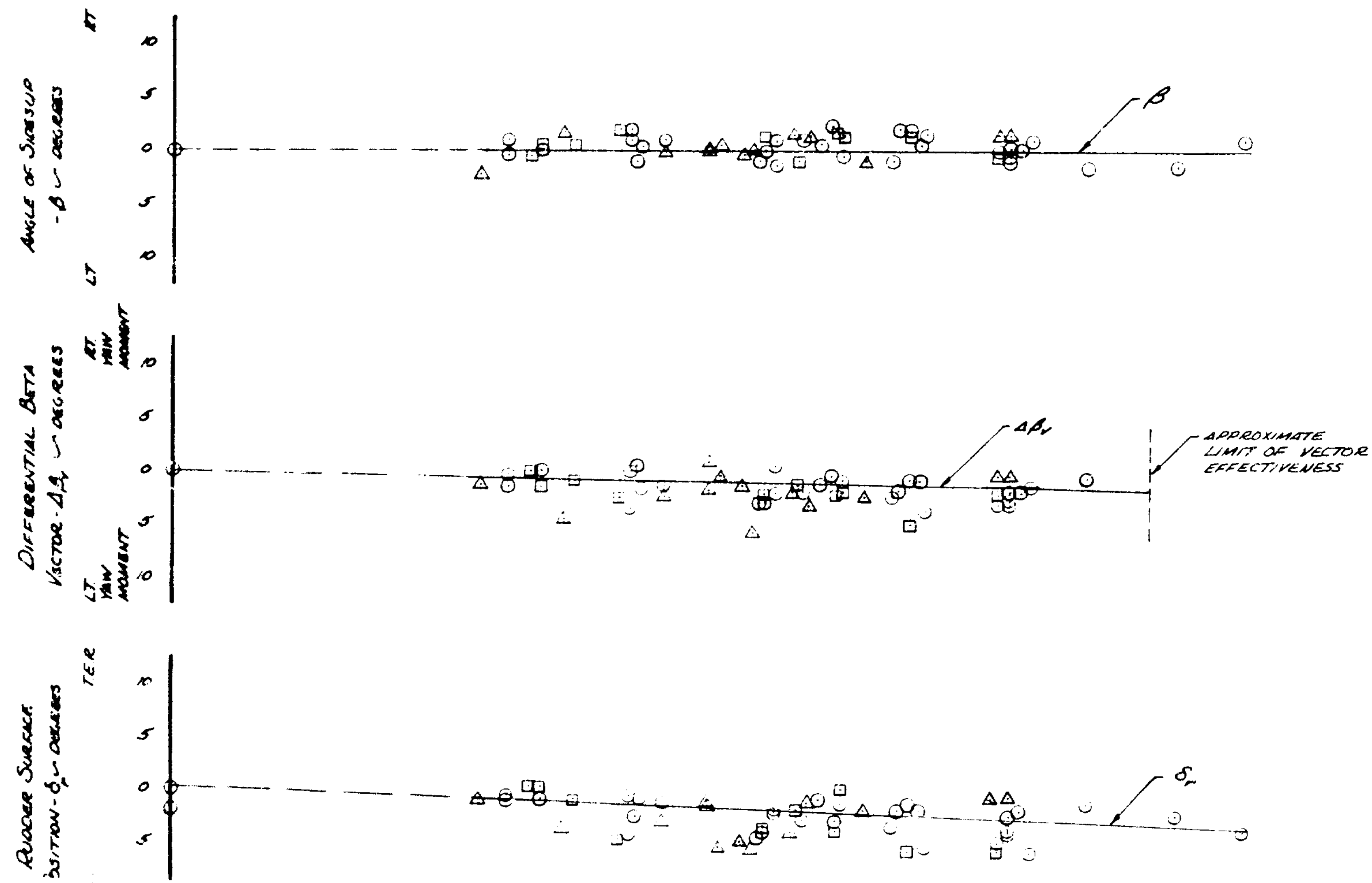

DIFFERENTIAL BETA STAGGER
$-\Delta\beta_s$ ~ DEGREES
RT. ROLL
LT. ROLL
$\Delta\beta_s$
APPROXIMATE LIMIT OF DIFFERENTIAL STAGGER EFFECTIVENESS.
LEFT AILERON
POSITION - δ_a ~ DEGREES
T.E.U.
T.E.D.
δ_a
LATERAL STICK
FORCE - F_a ~ POUNDS
RT.
LT.
F_a
LATERAL STICK
POSITION - δ_{s_a} ~ INCHES
δ_{s_a}
CALIBRATED AIRSPEED - V_c ~ KNOTS

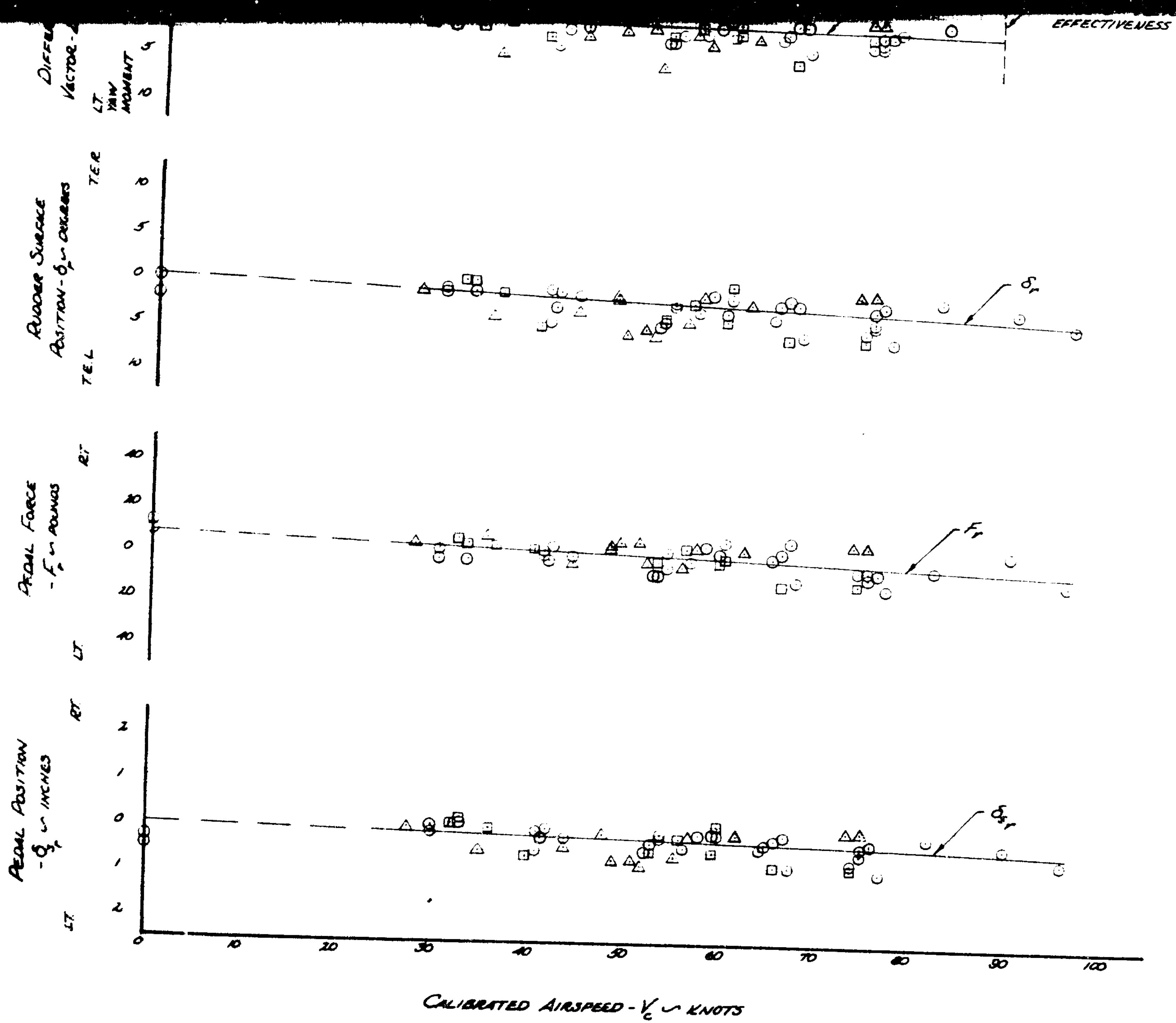
B

FIGURE No. 35
STATIC DIRECTIONAL TRIM STABILITY
XV-5A USA S/N 62-4505
FAN MODE

SYM	GEAR POS.	AVG ALT $-H_p$ ~ FT	ANGLE OF ATTACK ~ DEG	AVG. G.W. ~ LB	AVG. C.G. LOC. ~ IN.
△	DOWN	5750	-2	9810	241.5 (MID)
○	DOWN	5650	0	9730	241.4 (MID)
□	DOWN	5830	5	9670	241.1 (MID)

COLLECTIVE STICK POSITION = 100 % (UP)
LANDING GEAR FIXED DOWN WITH THE HEAT SHIELD INSTALLED.
MAXIMUM RUDDER PEDAL DISPLACEMENT = 3.5 IN. LT AND RT.





EFFECTIVENESS
DIFFE... VECTOR-...
LT. YAW MOMENT
RUDDER SURFACE POSITION - δ_r ~ DEGREES
T.E.R
T.E.L
δ_r
PEDAL FORCE - F_r ~ POUNDS
RT
LT
F_r
PEDAL POSITION - δ_{s_r} ~ INCHES
RT
LT
δ_{s_r}
CALIBRATED AIRSPEED - V_c ~ KNOTS

FIGURE No. 36

LOUVER VECTOR TRIM EFFECTIVENESS

XV-5A USA S/N 62-4505

FAN MODE

SYM	GEAR POS.	TRIM ANGLE OF ATTACK ~ DEG.	AVG ALT $-H_p$ ~ FT	AVG G.W ~ LB	AVG C.G. LOC ~ IN
○	DOWN	0	4820	9760	242.0 (MID)
◇	DOWN	0	5570	9810	241.1 (MID)

COLLECTIVE STICK POSITION = 100 % (UP)
LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED
HORIZONTAL STABILIZER POSITION = 20 DEG T.E.D.
MAXIMUM LONGITUDINAL STICK DISPLACEMENT = 6.2 IN FWD
8.0 IN AFT

SOLID SYMBOLS DENOTE TRIM POINTS.

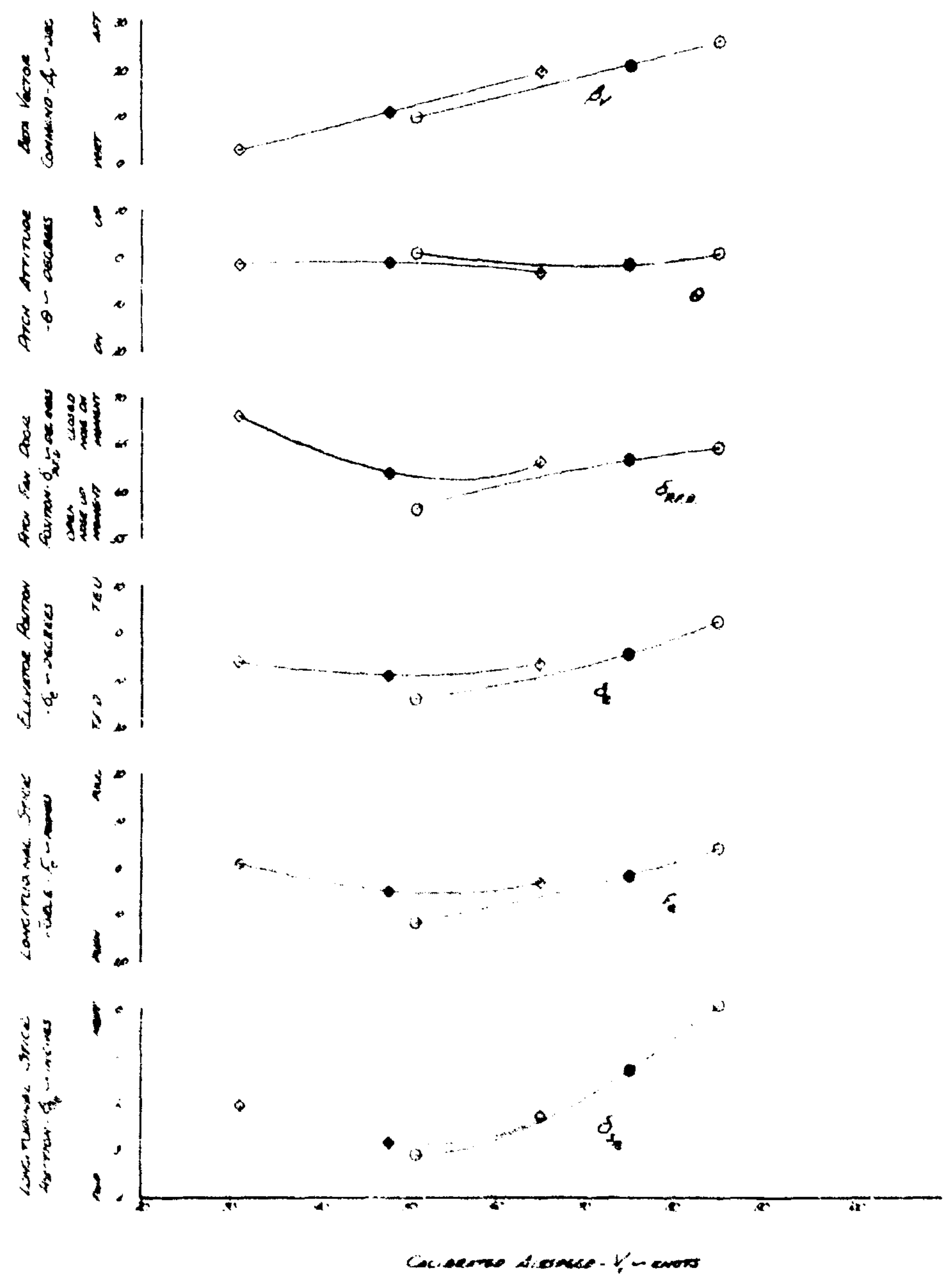


FIGURE NO. 37
HORIZONTAL STABILIZER TRIM EFFECTIVENESS
XV-5A USA S/N 62-4505
FAN MODE

SYM	TRIM A/S $-V_c$ ~ KTS	AVG. ALT. H_p ~ FT	AVG. G.W. ~ LB.	AVG. CG LOC ~ IN	TRIM ANGLE OF ATTACK $-\alpha$ ~ DEG.
O	80	5440	9730	241.6(MID)	0

COLLECTIVE STICK POSITION ~ 100 % (UP)
LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.
MAXIMUM LONGITUDINAL STICK DISPLACEMENT = 6.2 IN FWD
6.0 IN AFT

SOLID SYMBOLS DENOTE TRIM POINT.

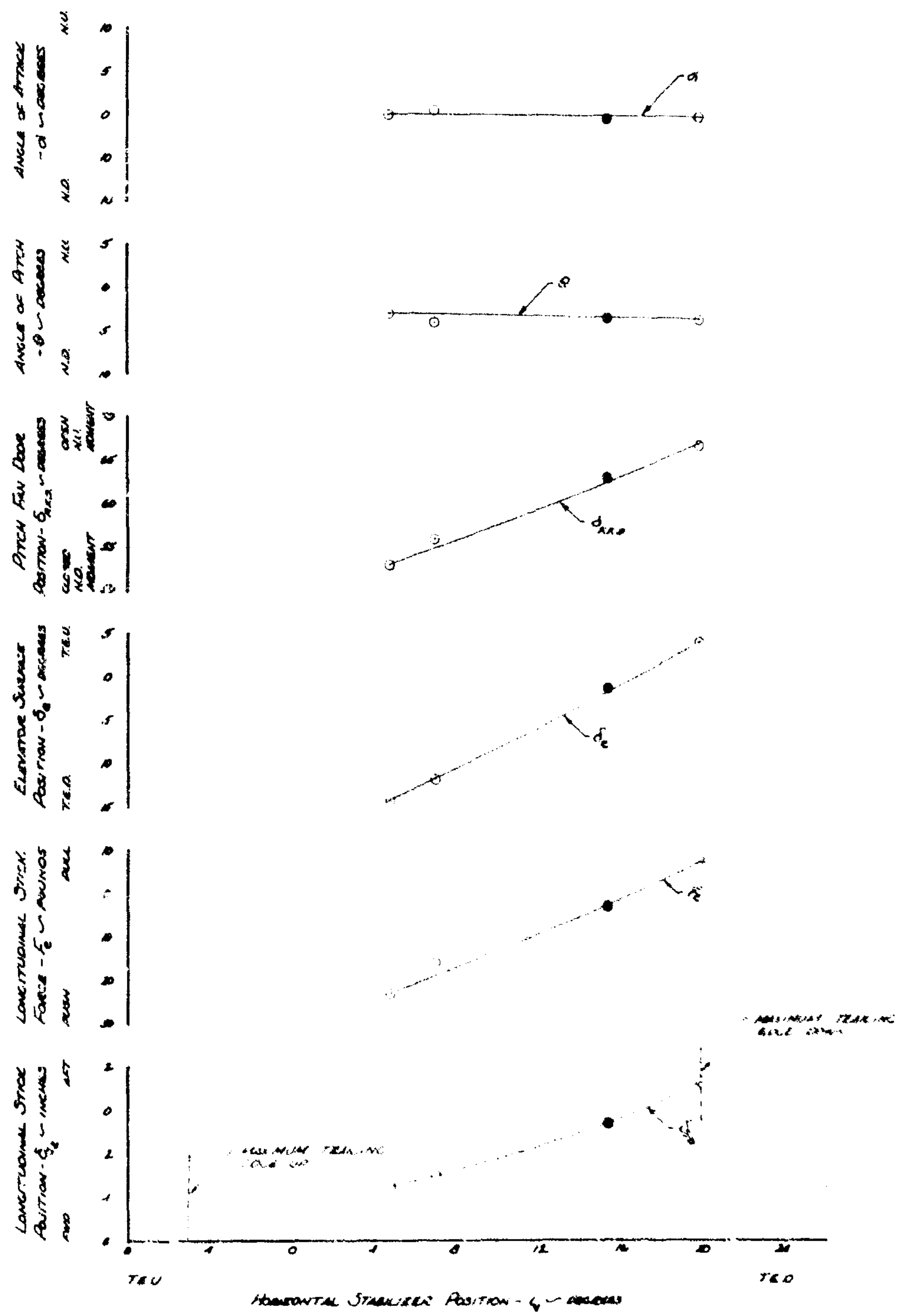


FIGURE No. 38
SIMULATED RUNAWAY HORIZONTAL
STABILIZER DURING FAN MODE FLIGHT
XV-5A USA % 62-4505

FLAP POSITION = 45 DEG.
GEAR POSITION = UP
COLLECTIVE STICK POS = 100% (UP)

A/C GROSS WEIGHT = 9,890 LB
A/C C.G. LOCATION = 241.1 in(MO)
SAS CONFIGURATION = OPTIMUM

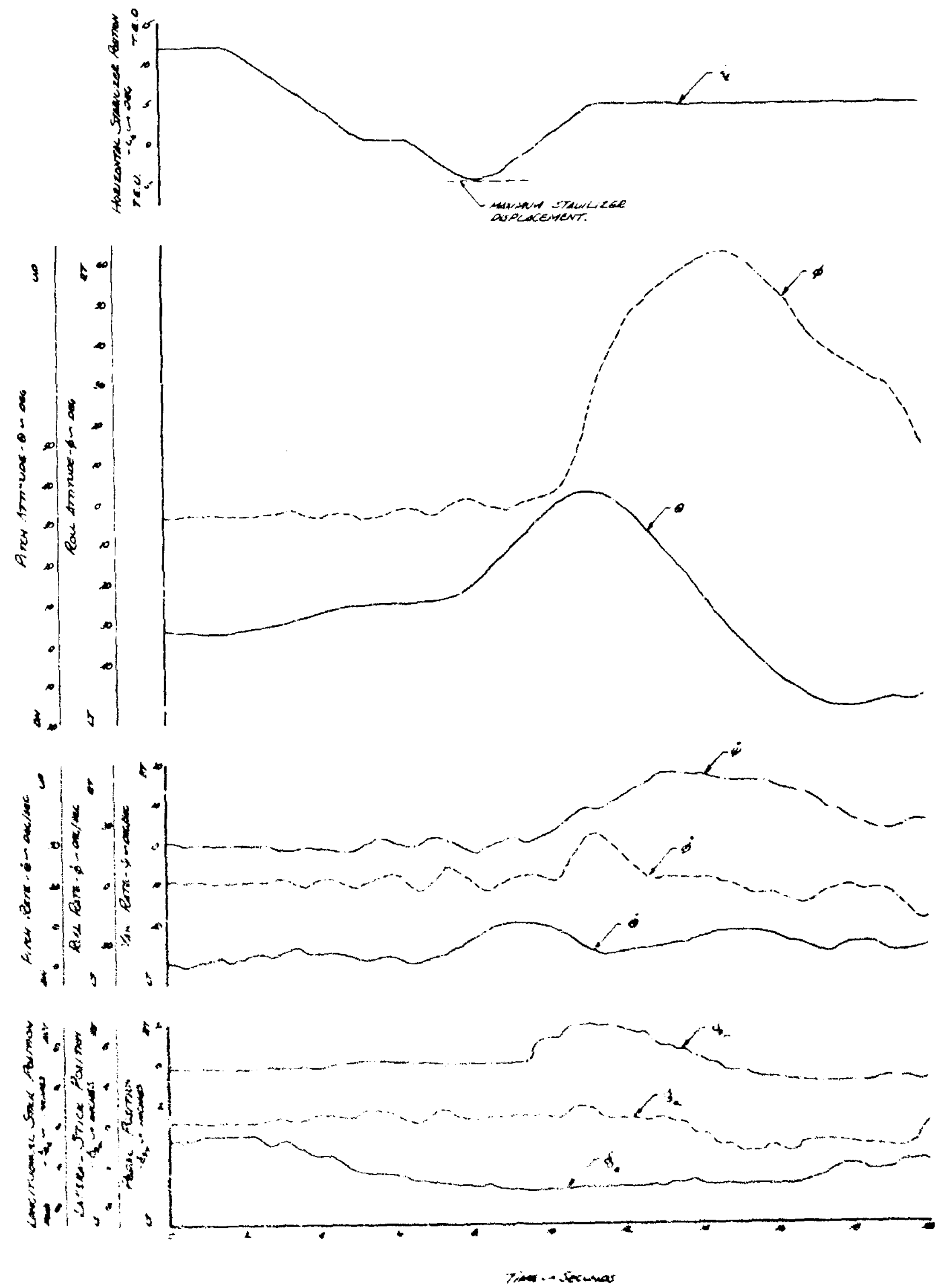


FIGURE No. 38 (CONTINUED)

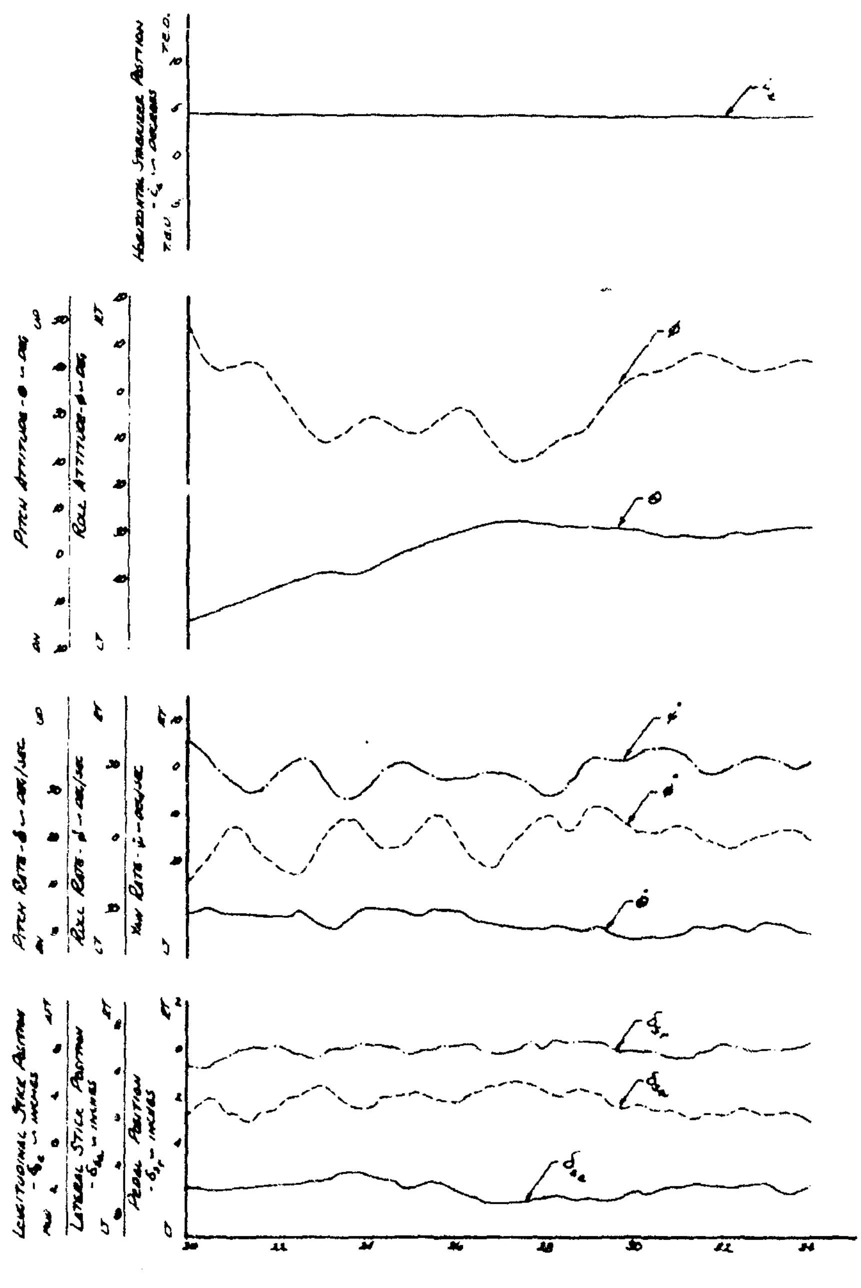


FIGURE No. 39
SIMULATED RUNAWAY HORIZONTAL
STABILIZER DURING FAN MODE FLIGHT
XV-5A USA S/N 62-4505

FLAP POSITION = 45 DEG
GEAR POSITION = UP
COLLECTIVE STICK POS = 100% (UP)

AVG GROSS WEIGHT = [illegible] LB
AVG. C.G. LOCATION = [illegible]
SAS CONFIGURATION = OPTIMUM

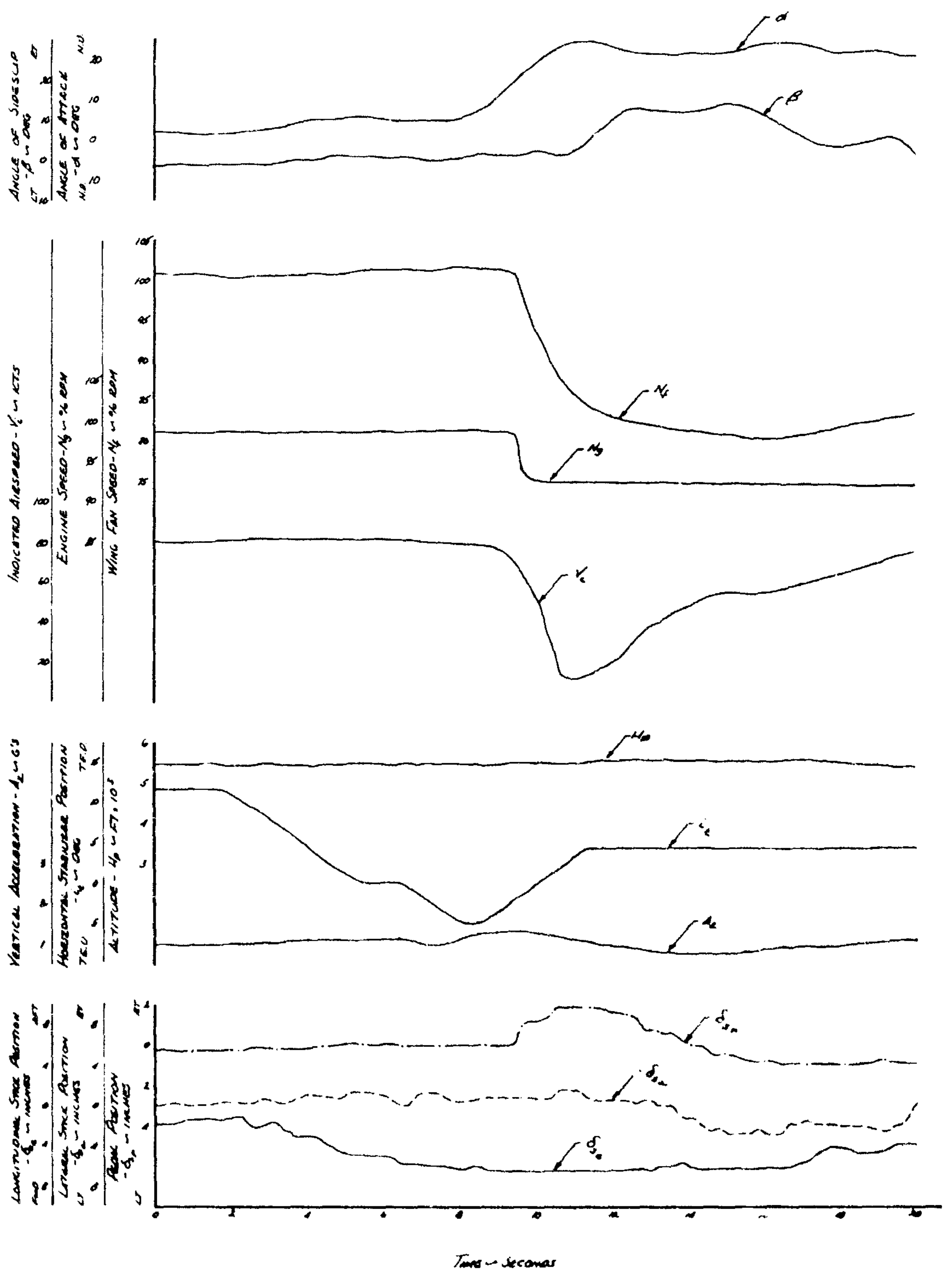


FIGURE No. 39 (CONTINUED)

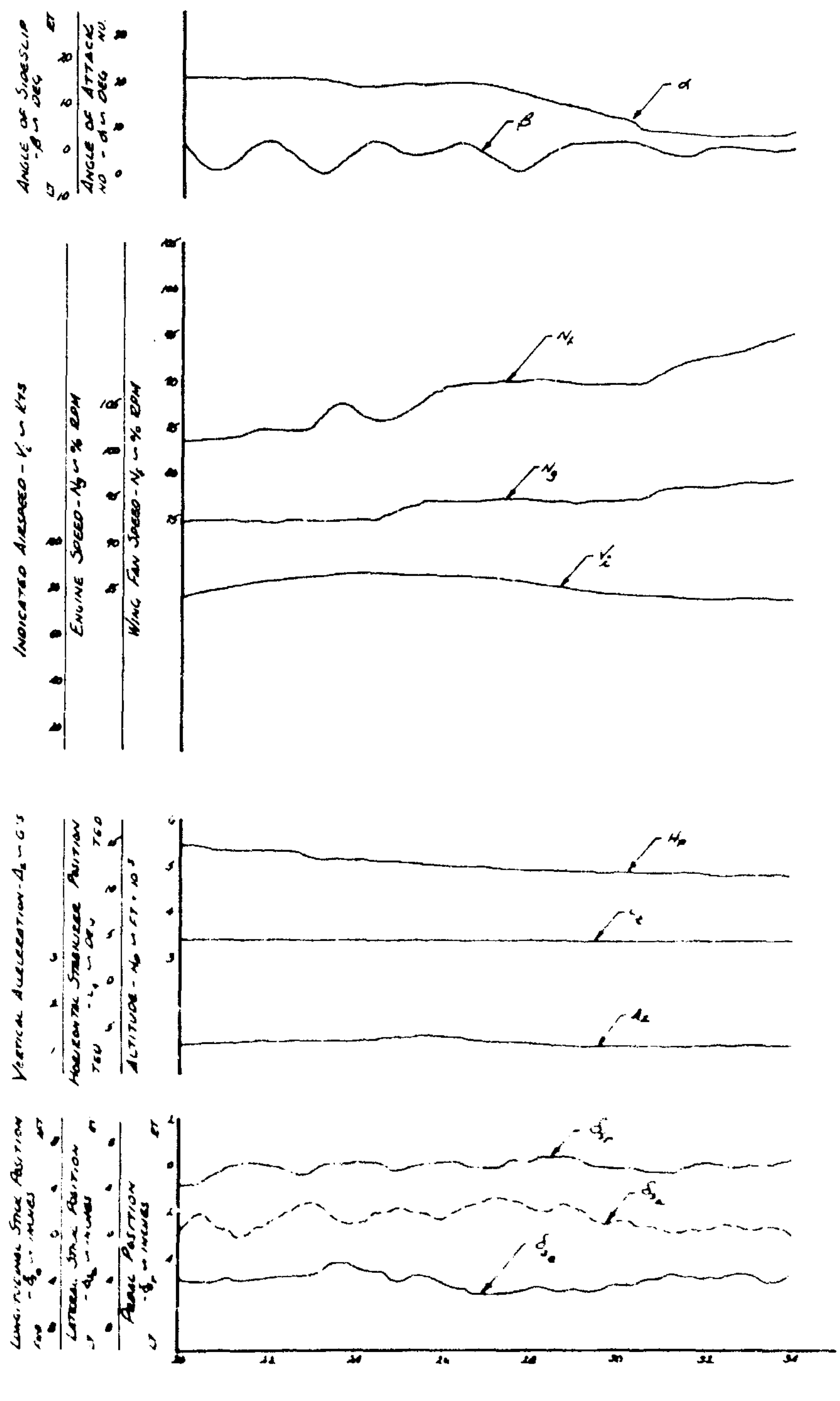


FIGURE NO. 40
SUMMARY OF
STATIC LONGITUDINAL STABILITY
XV-5A USA S/N 62-4505
FAN MODE

SYM	GEAR POS.	ANGLE OF ATTACK ~ DEG.	AVG ALT -H_p ~ FT	AVG G.W ~ LB	AVG C.G LOC ~ IN.
△	DOWN	0	5420	9550	241.7 IN (MID)
◇	DOWN	5	5170	10030	240.9 IN (MID)

DERIVATIVES TAKEN AT THE TRIM POINT FROM FIG. NO. 41, APPENDIX I.

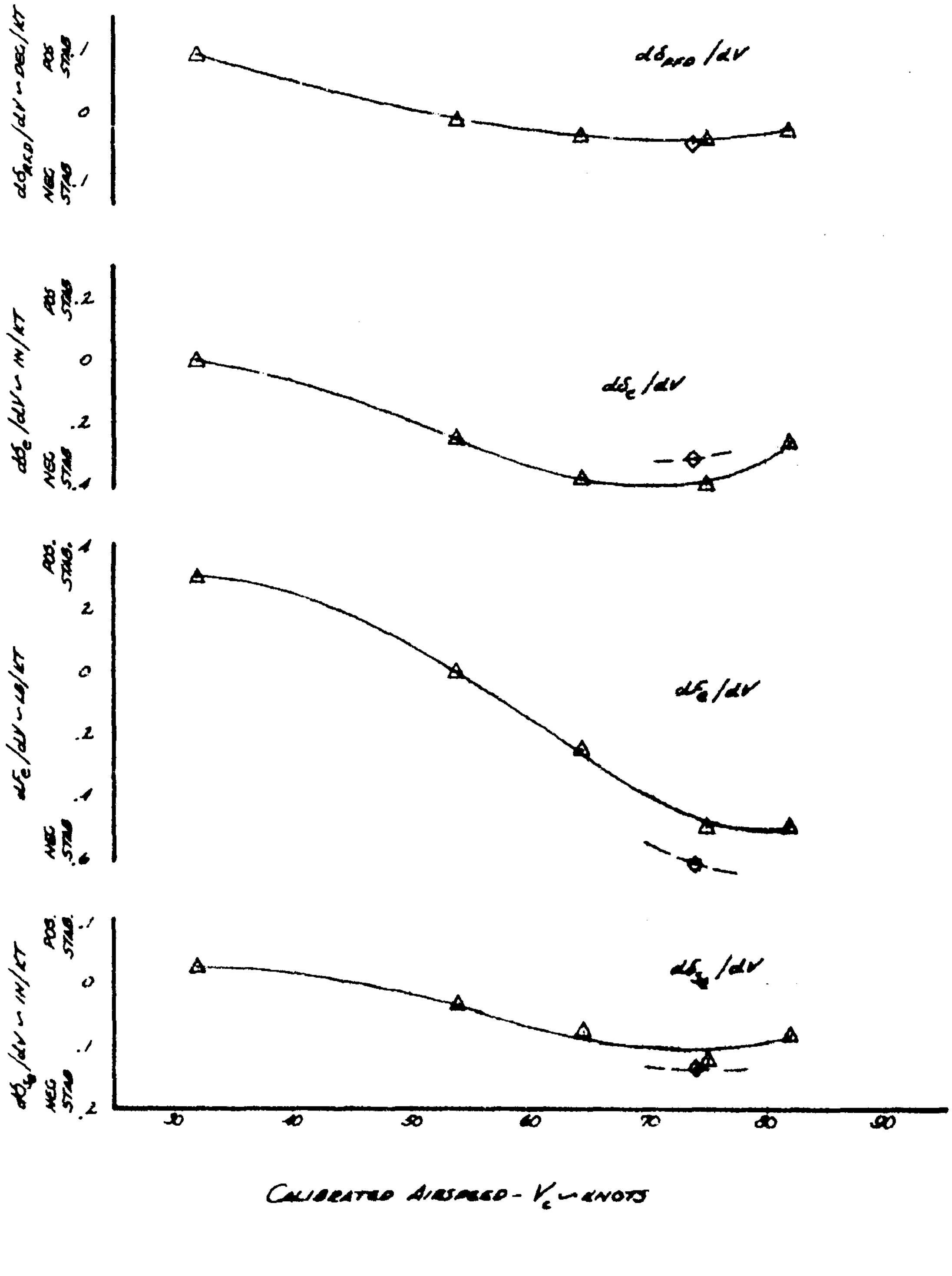


FIGURE No. 41
STATIC LONGITUDINAL STABILITY
XV-5A USA S/N 624505
FAN MODE

SYM	AVG ALT H_p ~ FT	AVG G.W ~ LB	AVG C.G. LOC ~ IN	HOR STAB POS ~ DEG
○	4620	9910	241.4(MID)	21 TED
□	5240	9700	241.7(MID)	21 TED
△	5750	9950	241.9(MID)	21 TED
◇	5250	9460	241.9(MID)	19.6 TED
▽	5470	10830	240.9(MID)	21 TED
	5800	9770	240.7(MID)	21 TED

COLLECTIVE STICK POSITION = 100% (UP)
LANDING GEAR FIXED DOWN WITH THE HEAT SHIELD INSTALLED
MAXIMUM LONGITUDINAL STICK DISPLACEMENT = 6.2 IN FWD
6.0 IN AFT

SOLID SYMBOLS DENOTE TRIM POINTS

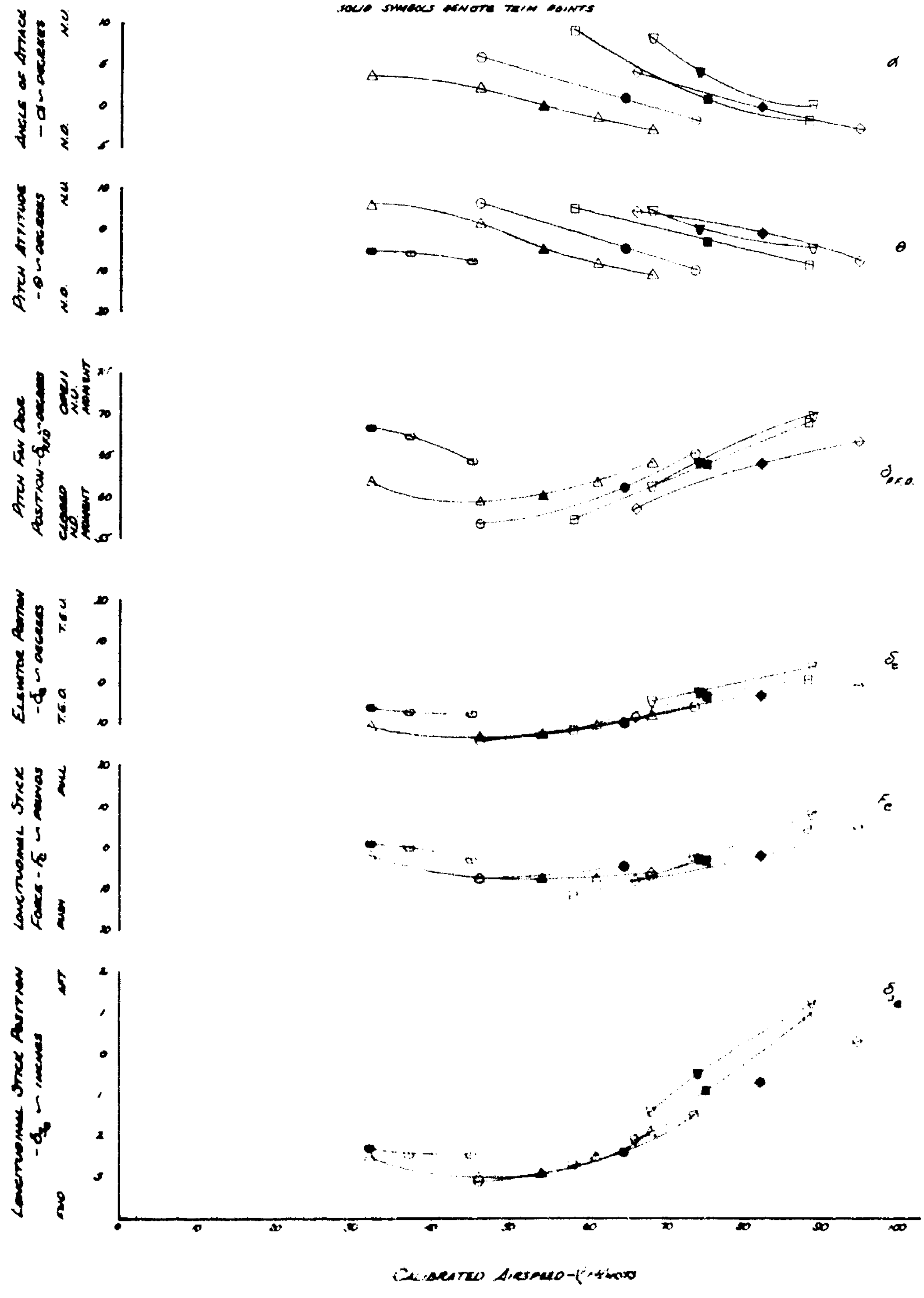


FIGURE No. 42
SUMMARY OF
STATIC LATERAL-DIRECTIONAL STABILITY
XV-5A USA S/N 62-4505
FAN MODE

GEAR POSITION = DOWN
AVG ALTITUDE - H_p = 5650 FT
AVG GROSS WEIGHT = 9880 LB
AVG. C.G. LOC = 241.1 IN (AMO)
COLLECTIVE STICK POSITION = 100 % (UP)

DERIVATIVE TAKEN AT
THE TRIM POINT FROM
FIG. NO. 43 THROUGH 47
SECTION 5, APPENDIX I.

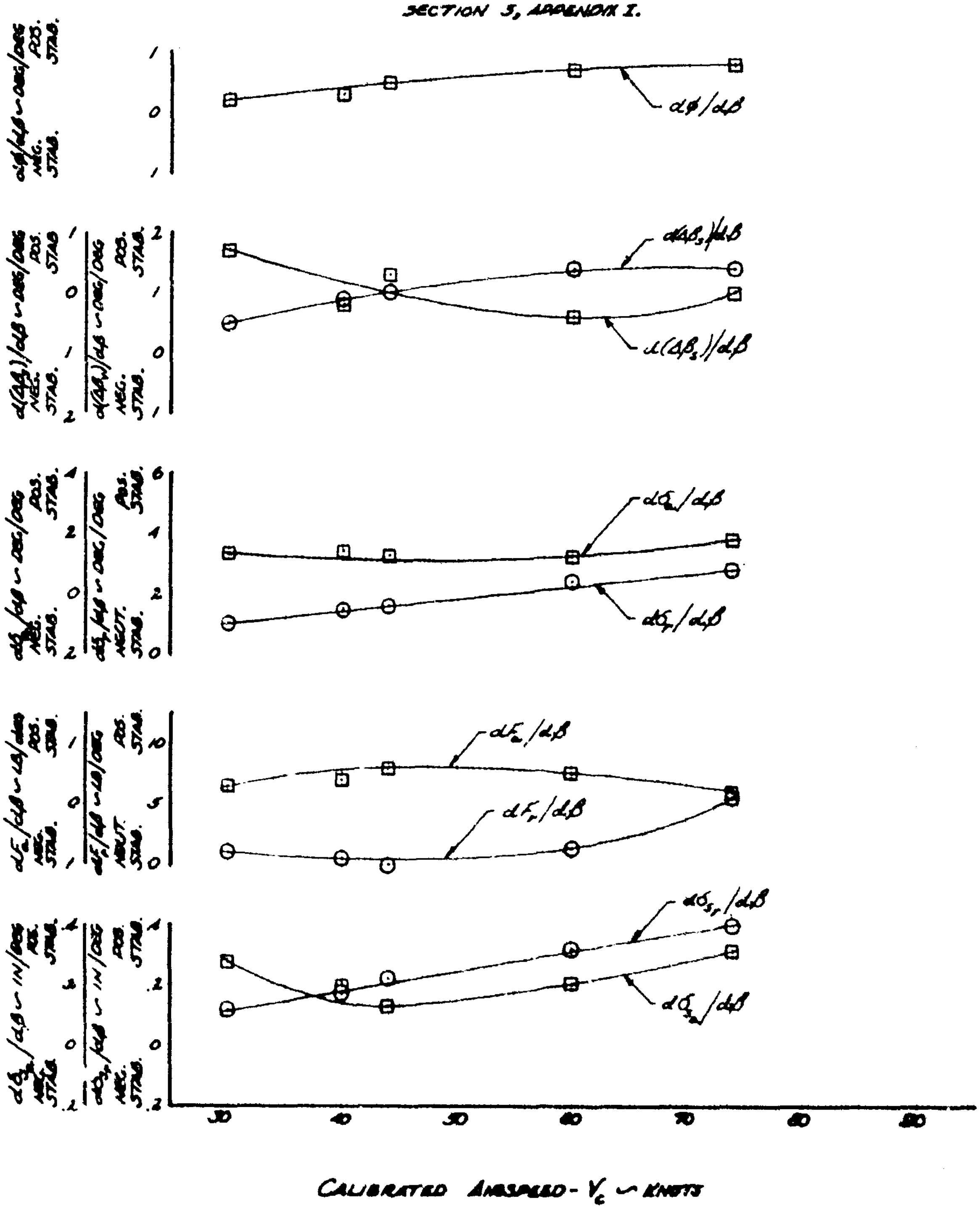


FIGURE No. 43
STATIC LATERAL-DIRECTIONAL STABILITY
XV-5A USA S/N 62-4505
FAN MODE

TRIM A/S = 30 KCAS
AVG H_P = 5880 FT
LANDING GEAR : DOWN

AVG G.W. = 9860 LB
AVG. C.G. = 241.1 IN (MID)

COLLECTIVE STICK POSITION = 100 % (UP)
LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.
SOLID SYMBOLS DENOTE TRIM POINTS

MAXIMUM CONTROL DISPLACEMENT
LONGITUDINAL = 6.0 IN. AFT, 6.2 IN FWD
LATERAL = 3.0 IN. RT, 3.2 IN. LT.
PEDAL = 3.5 IN. RT, 3.5 IN LT.

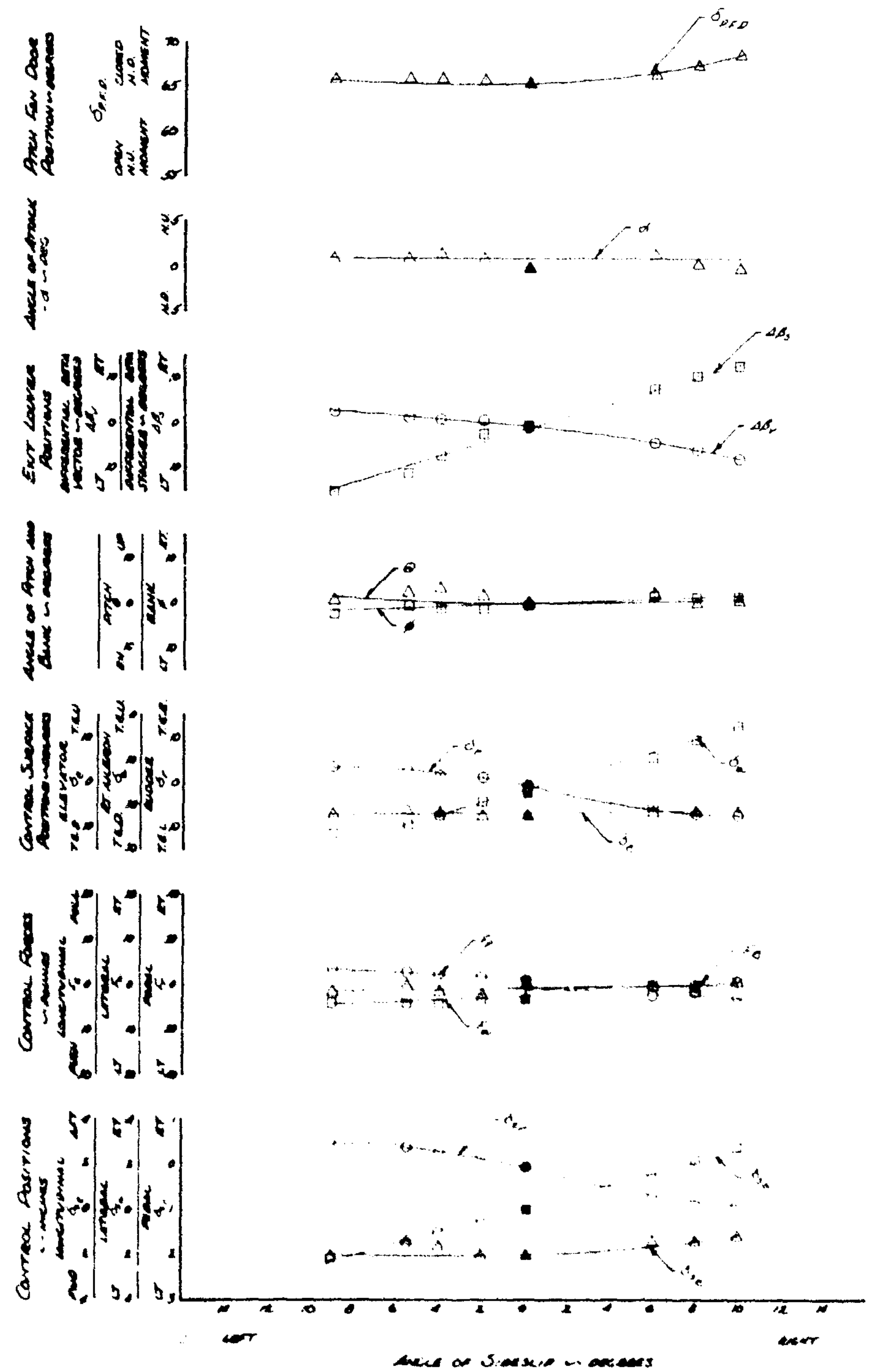


FIGURE No. 44
STATIC LATERAL-DIRECTIONAL STABILITY
XV-5A USA S/N 62-4505
FAN MODE

TRIM A/S = 44 KCAS
AVG H_p = 6200 FT.
LANDING GEAR : DOWN

AVG. G.W. = 9900 LB.
AVG. C.G. = 242.1 IN (MID)
SAS CONFIG. = OPTIMUM

COLLECTIVE STICK POSITION = 100% (UP).
LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.
SHADED SYMBOLS DENOTE TRIM POINTS.

MAXIMUM CONTROL DISPLACEMENT
LONGITUDINAL = 6.2 IN FWD, 6.0 IN AFT
LATERAL = 3.3 IN. RT 3.2 IN LEFT
PEDAL = 3.5 IN. LT. 3.6 IN. RT.

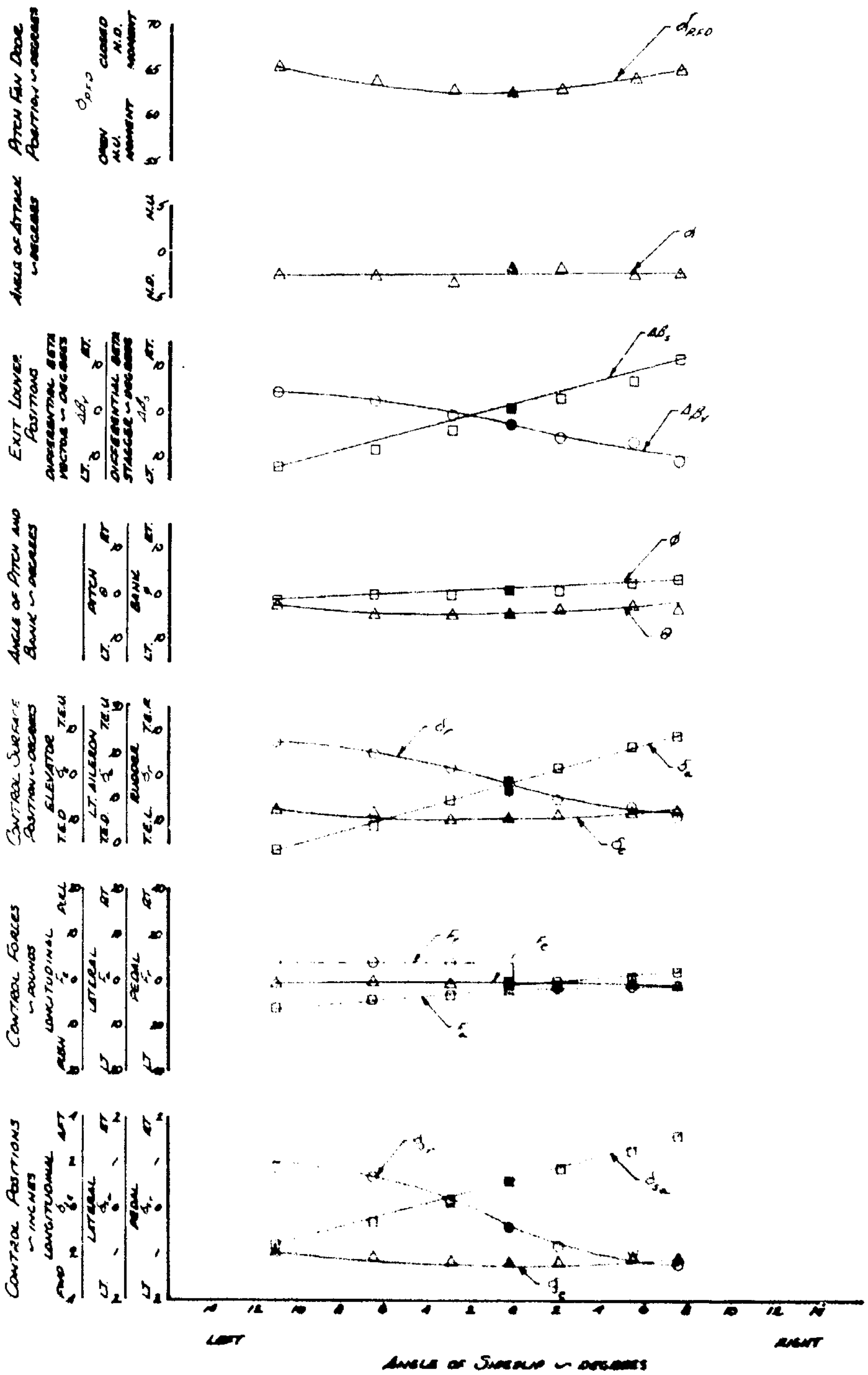


FIGURE No. 45
STATIC LATERAL-DIRECTIONAL STABILITY
XV-5A USA S/N 62-4505
FAN MODE

TRIM A/S = 80 KCAS
AVG. H_p = [illegible]70 FT
LANDING GEAR : DOWN

AVG. G.W. = 9870 LB
AVG. C.G. = 241.4 IN(MAC)
SAS CONFIG = OPTIMUM

COLLECTIVE STICK POSITION = 100% (UP)
LANDING GEAR FIXED DOWN WITH THE HEAT SHIELD INSTALLED.
SOLID SYMBOLS DENOTE TRIM POINTS.

MAXIMUM CONTROL DISPLACEMENT
LONGITUDINAL = 6.2 IN. FWD, 6.0 IN AFT
LATERAL = 3.9 IN. RT, 3.2 IN. LT.
PEDAL = 3.5 IN. RT, 3.5 IN LT.

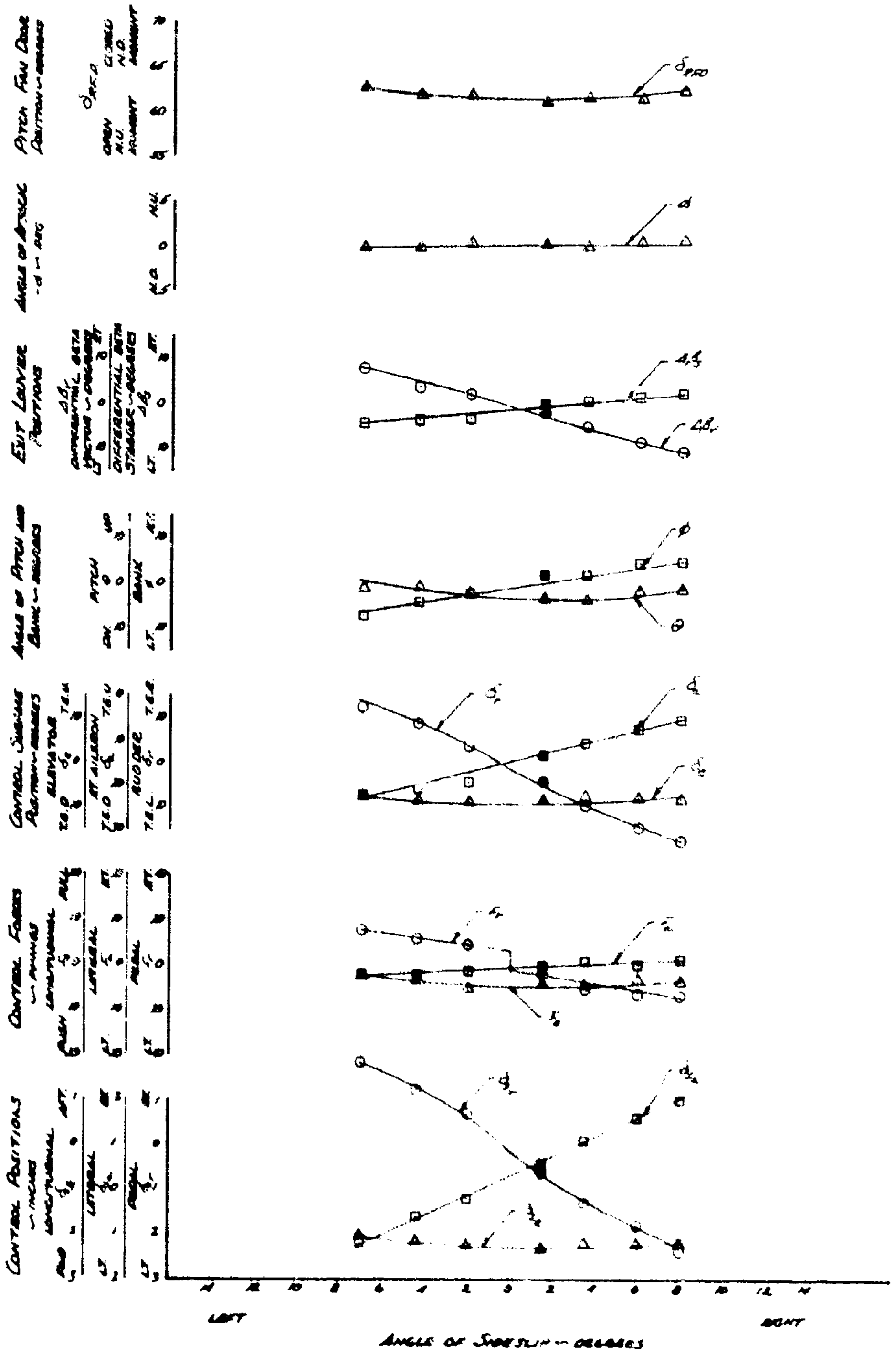


FIGURE No. 46
STATIC LATERAL-DIRECTIONAL STABILITY
XV-5A USA S/N 62-4505
FAN MODE

TRIM A/S = 76 KCAS
AVG H_p = 4020 FT
LANDING GEAR: DOWN

AVG. G.W. = 10000 LB
AVG C.G. = 238.4 IN(MID)
SAS CONFIG = OPTIMUM

COLLECTIVE STICK POSITION = 100%(UP).
LANDING GEAR FIXED DOWN WITH THE HEAT SHIELD INSTALLED.
SOLID SYMBOLS DENOTE TRIM POINTS.

MAXIMUM CONTROL DISPLACEMENT
LONGITUDINAL = 6.2 IN.FWD., 6.0 IN.AFT
LATERAL = 3.0 IN.RT., 3.2 IN.LT.
PEDAL = 3.5 IN.RT., 3.5 IN.LT.

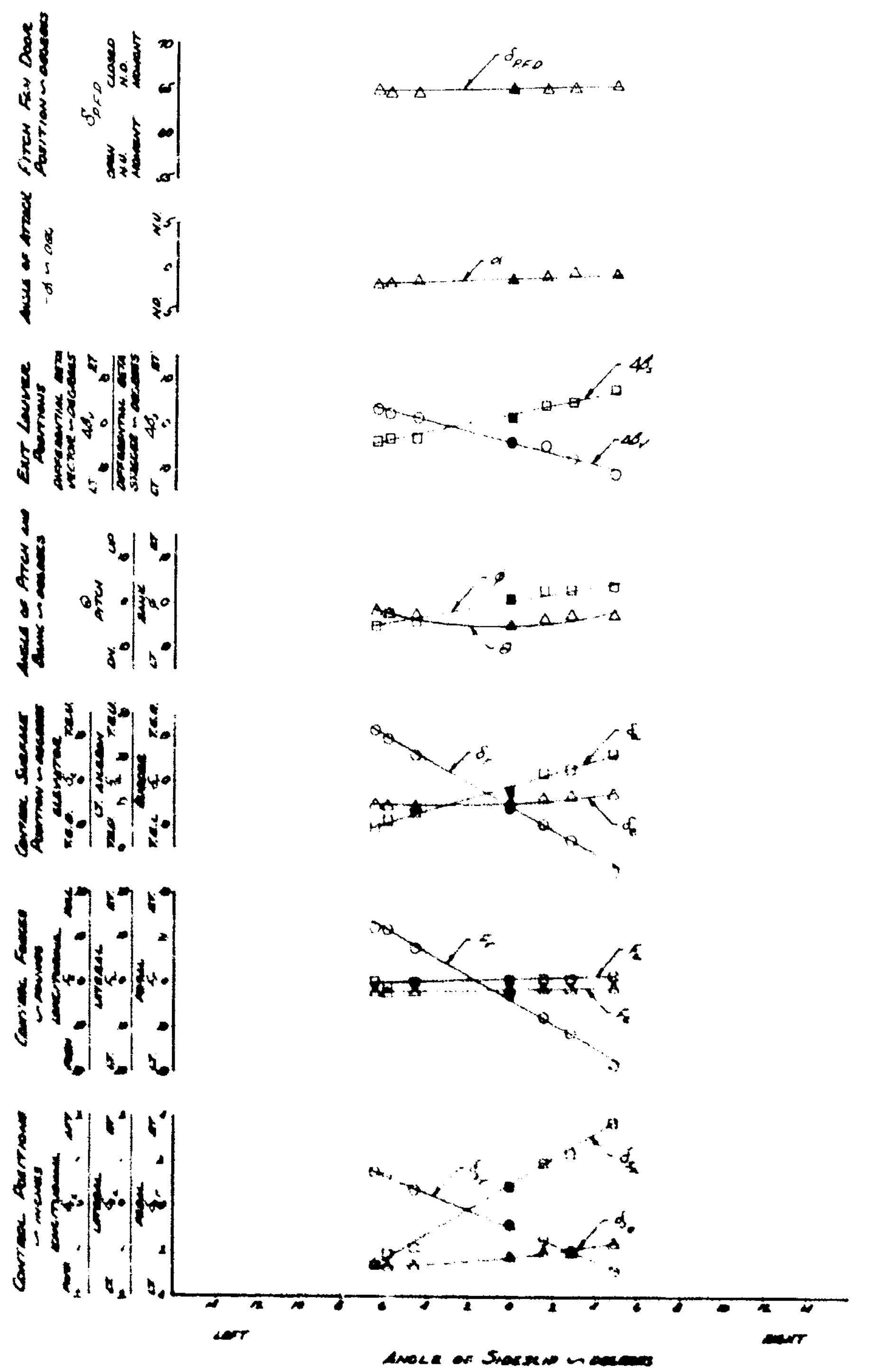


FIGURE No. 47
STATIC LATERAL-DIRECTIONAL STABILITY
XV-5A USA S/N 62-4505
FAN MODE

TRIM A/S = 40 KCAS
AVG H_p = 5430 FT
LANDING GEAR: DOWN

AVG. G.W. = 9720 LB
AVG C.G. = 241.3 IN(MID)
SAS CONFIG = OPTIMUM

COLLECTIVE STICK POSITION = 100 % (UP)
LANDING GEAR FIXED DOWN WITH THE HEAT SHIELD INSTALLED.
SOLID SYMBOLS DENOTE TRIM POINTS

MAXIMUM CONTROL DISPLACEMENT
LONGITUDINAL = 6.2 IN. FWD, 6.0 IN. AFT
LATERAL = 3.0 IN. RT, 3.3 IN. LT.
PEDAL = 3.5 IN. RT, 3.5 IN. LT.

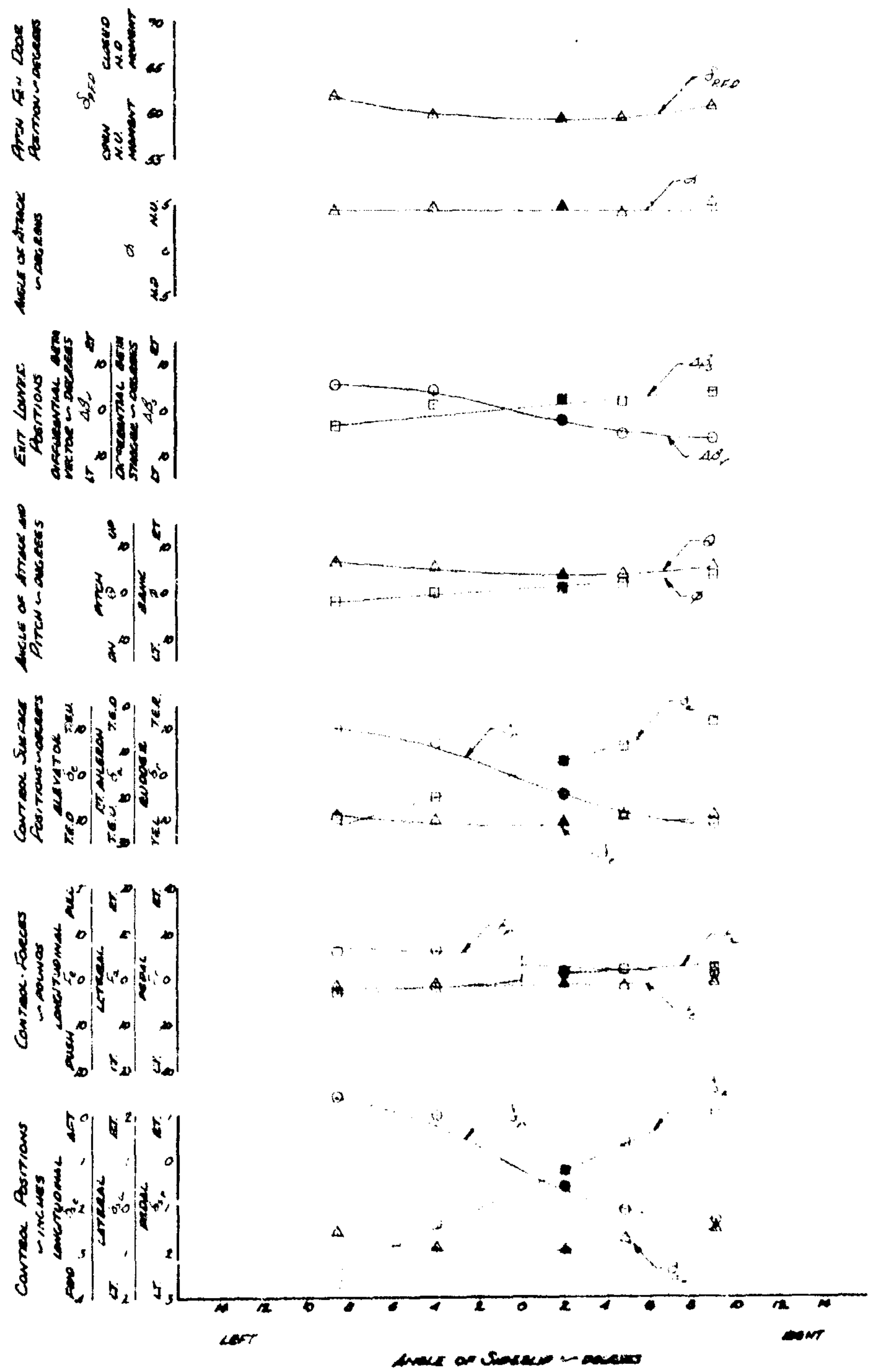


FIGURE No. 48
SIDEWARD FLIGHT
STATIC TRIM STABILITY
FAN MODE

WHEEL HEIGHT = 20 TO 30 FT.

AVG. ALT. = 2240 FT. AVG. G.W. = 9600 LB.

LANDING GEAR DOWN AVG. C.G. = 241.0 IN.

COLLECTIVE STICK POS = 37-50% (UP)

BETA VECTOR ANGLE = 7.6 DEG. FWD.

MAXIMUM CONTROL DISPLACEMENT

LONGITUDINAL	6.2 IN. FWD.	6.0 IN. AFT
LATERAL	3.4 IN. RT.	3.2 IN. LT.
PEDAL	3.5 IN. RT.	3.5 IN. LT.

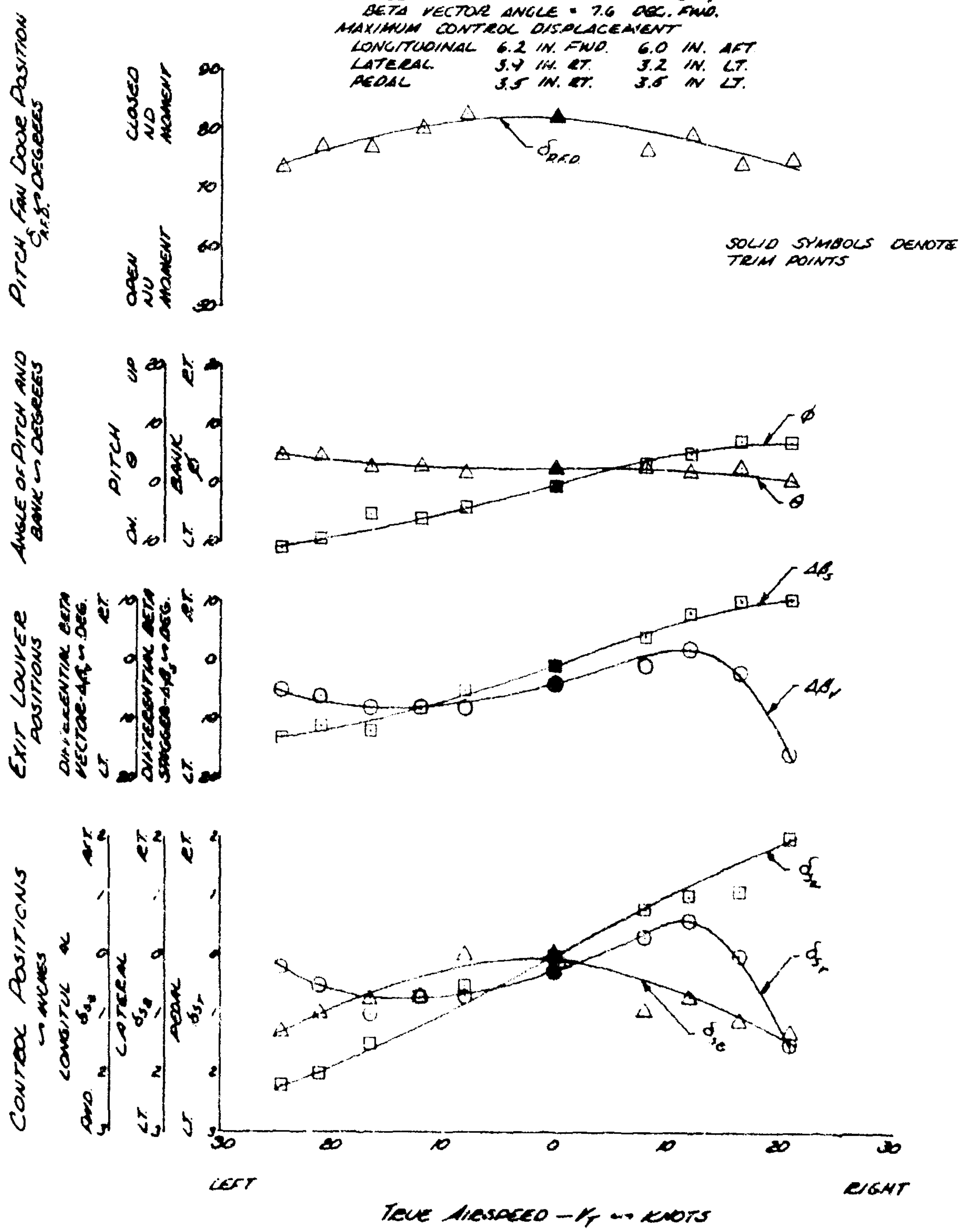


FIGURE No. 49
LOW SPEED FORWARD AND REARWARD FLIGHT STATIC TRIM STABILITY
FAN MODE

WHEEL HEIGHT = 20 TO 30 FT.

AVG. ALT. = 2240 FT. AVG. G.W. = 9600 LB.
LANDING GEAR DOWN AVG. C.G. = 241.0 IN.

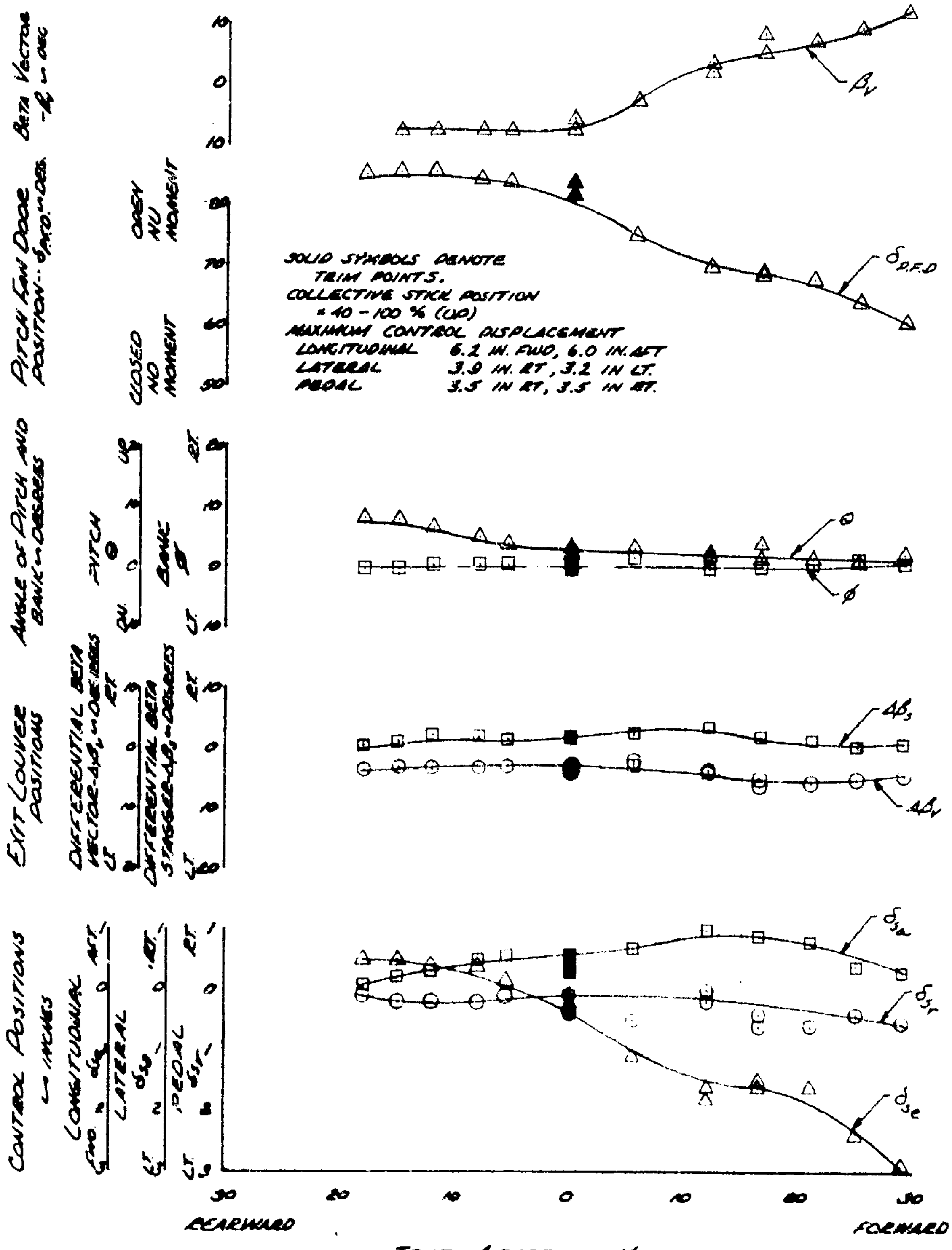


FIGURE No. 50
DYNAMIC LONGITUDINAL STABILITY
XV-5A USA S/N 62-4505
FAN MODE

FLT. CONDITION: HOVER
AVG. PRESSURE ALT = 2350 FT
COLLECTIVE POS = 70%
HOR. STABILIZER POS. = 21°
AVG. G.W = 10010 LB
AVG CG LOC = 241.1 IN (MID)
SAS CONFIG = OPTIMUM
WHEEL HT. ABOVE GRND = 25 FT.
LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.

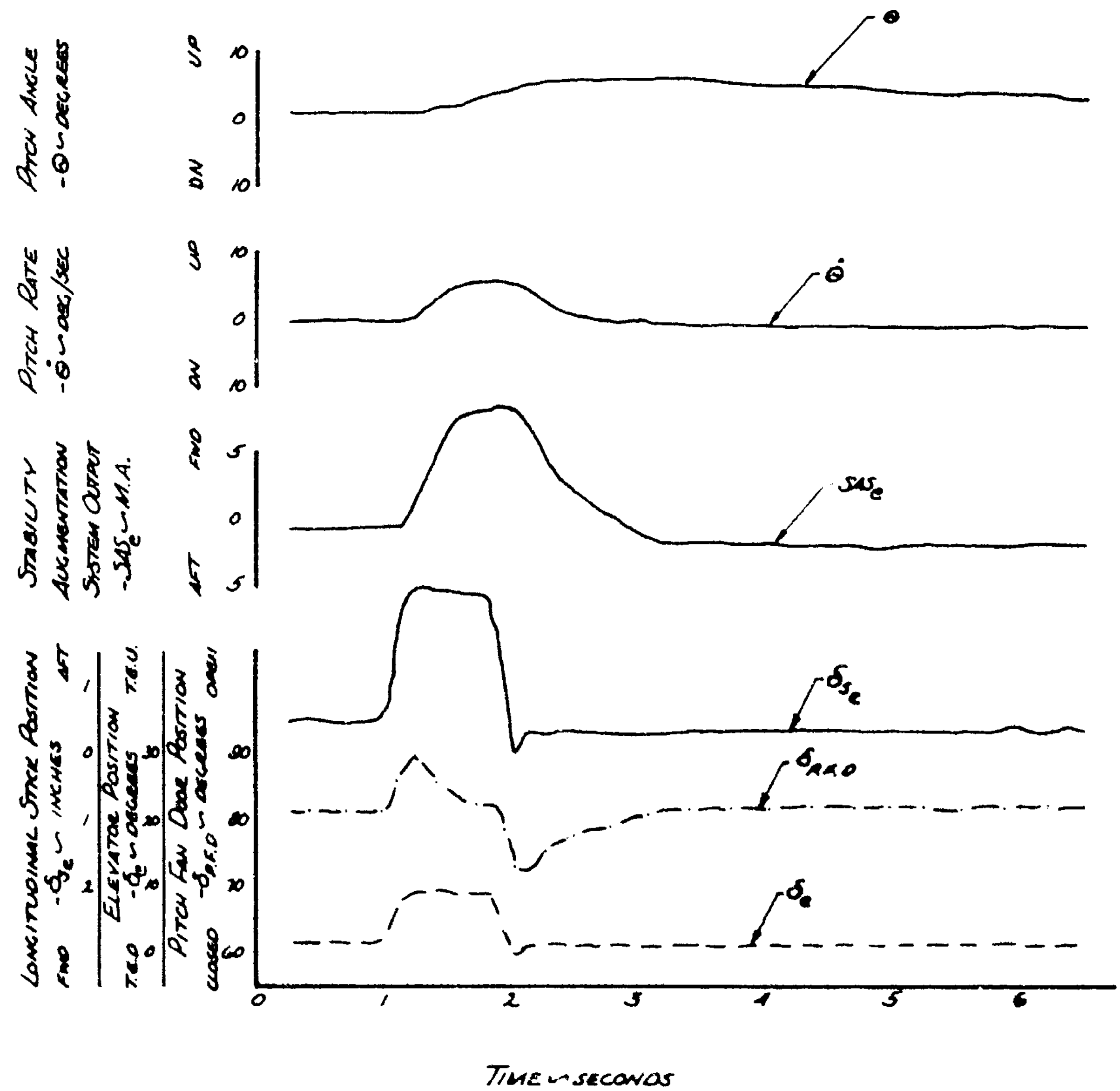


FIGURE No. 51
DYNAMIC LONGITUDINAL STABILITY
XV-5A USA S/N 62-4505
FAN MODE

FLT CONDITION: HOVER
AVG. PRESSURE ALT = 2310 FT
COLLECTIVE POS = 70 %
HOR. STABILIZER POS. = 21°

AVG G.W = 10010 LB
AVG CG LOC = 241.1 IN(MID)
SAS CONFIG = OPTIMUM
WHEEL HT. ABOVE GRND = 25 FT

LANDING GEAR FIXED
DOWN WITH HEAT SHIELD
INSTALLED.

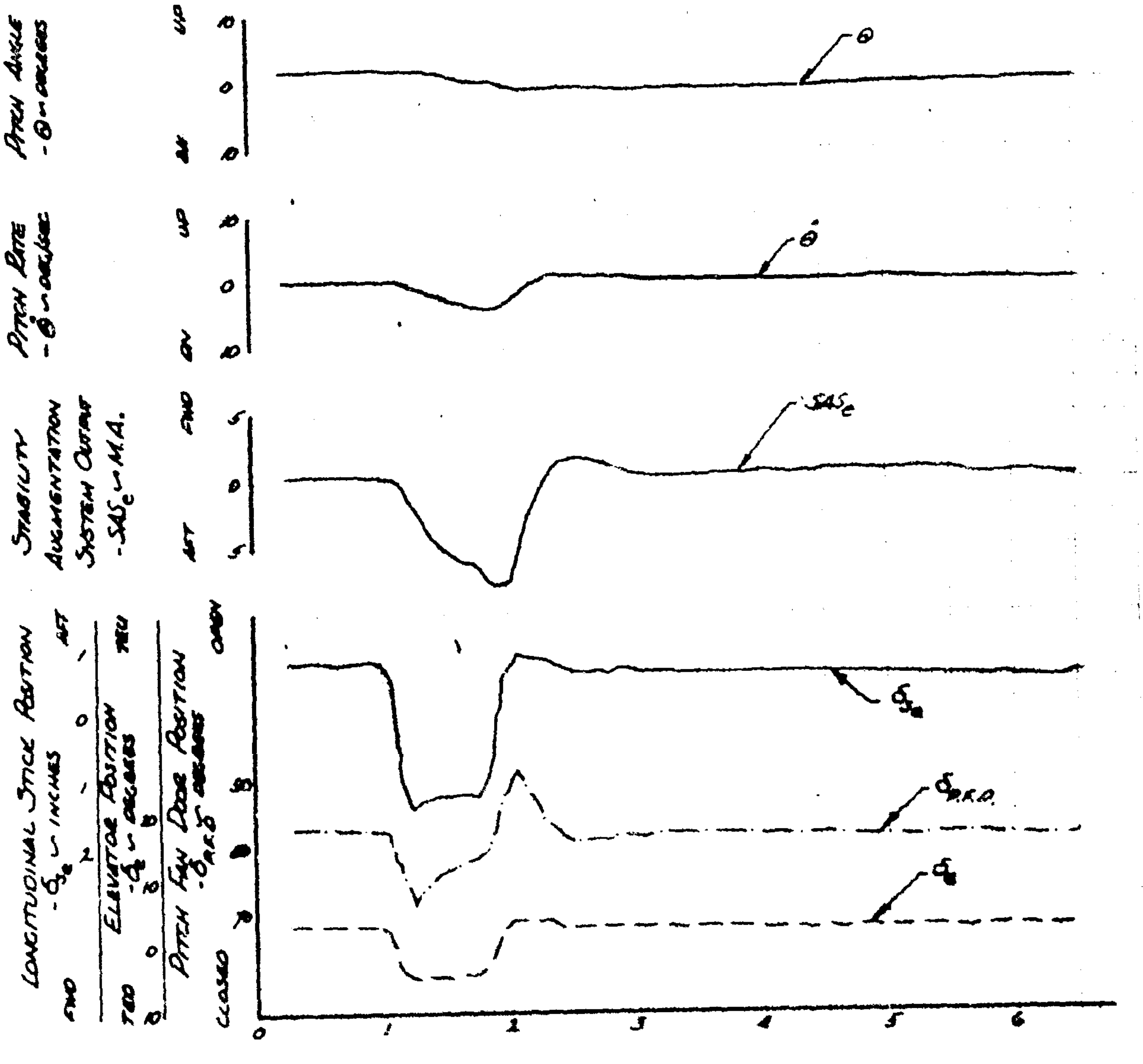


FIGURE No. 52
DYNAMIC LONGITUDINAL STABILITY
XV-5A USA S/N 624505
FAN MODE

FLT. CONDITION: LEVEL FLT
TRIM AIRSPEED = 45 KCAS
TRIM ANGLE OF ATTACK = -1.2°
COLLECTIVE POS = 100 %
HOR. STABILIZER POS. = 2.1°

AVG. PRESSURE ALT = 6510 FT
AVG. G.W = 8570 LB
AVG. CG LOC. = 241.4 IN (MHB)
SAS CONFIG = OPTIMUM
LANDING GEAR FIXED DOWN
WITH HEAT SHIELD INSTALLED

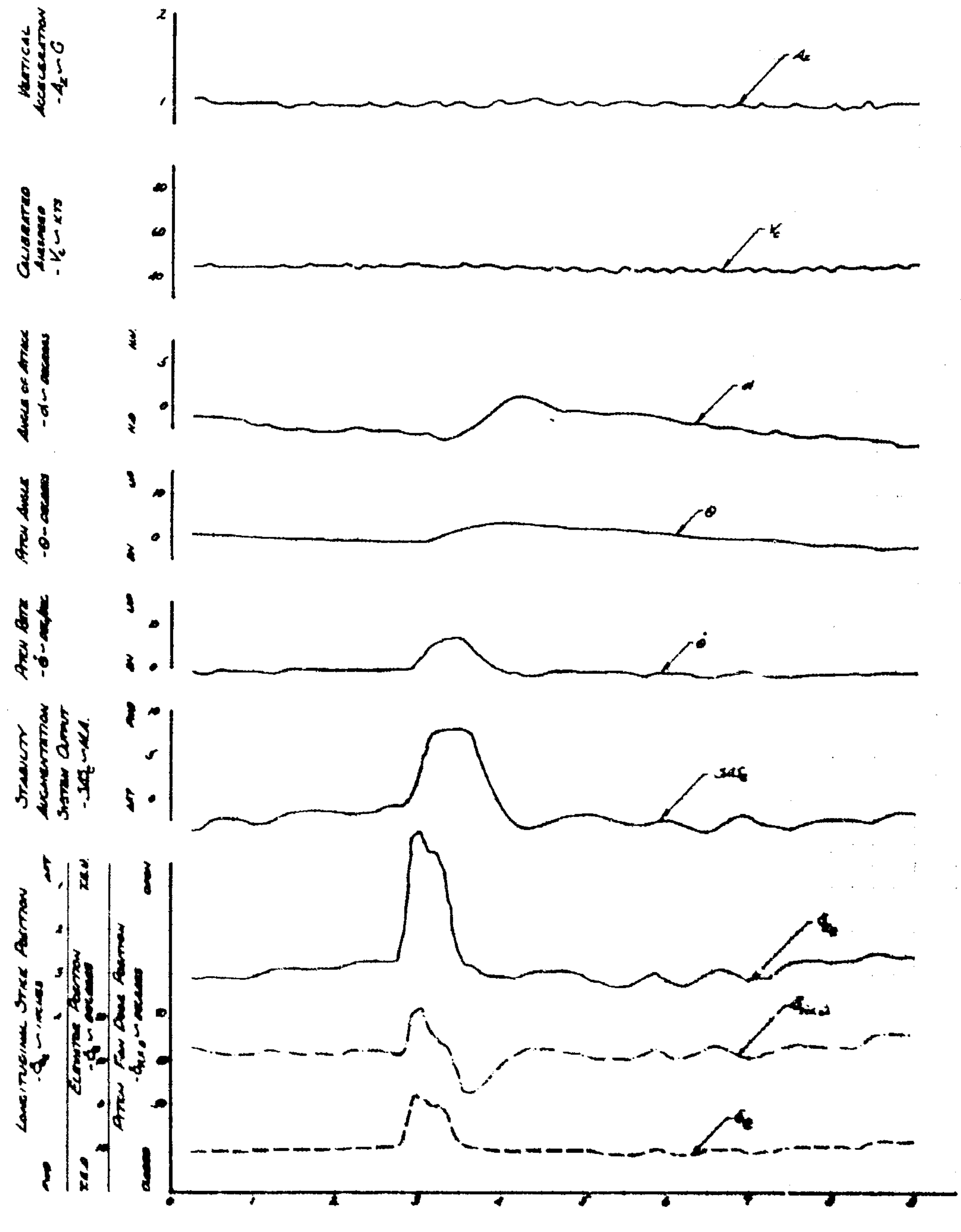


FIGURE No. 53
DYNAMIC LONGITUDINAL STABILITY
XV-5A USA S/N 624505
FAN MODE

FLT CONDITION: LEVEL FLT
TRIM AIRSPEED = 50 KCAS
TRIM ANGLE OF ATTACK = -2.1°
COLLECTIVE POS = 100%
HOR. STABILIZER POS. = 21°

AVG PRESSURE ALT = 6470 FT.
AVG G.W = 9570 LB
AVG CG LOC = 241.4 IN (MID)
SAS CONFIG = OPTIMUM
LANDING GEAR FIXED DOWN WITH
HEAT SHIELD INSTALLED

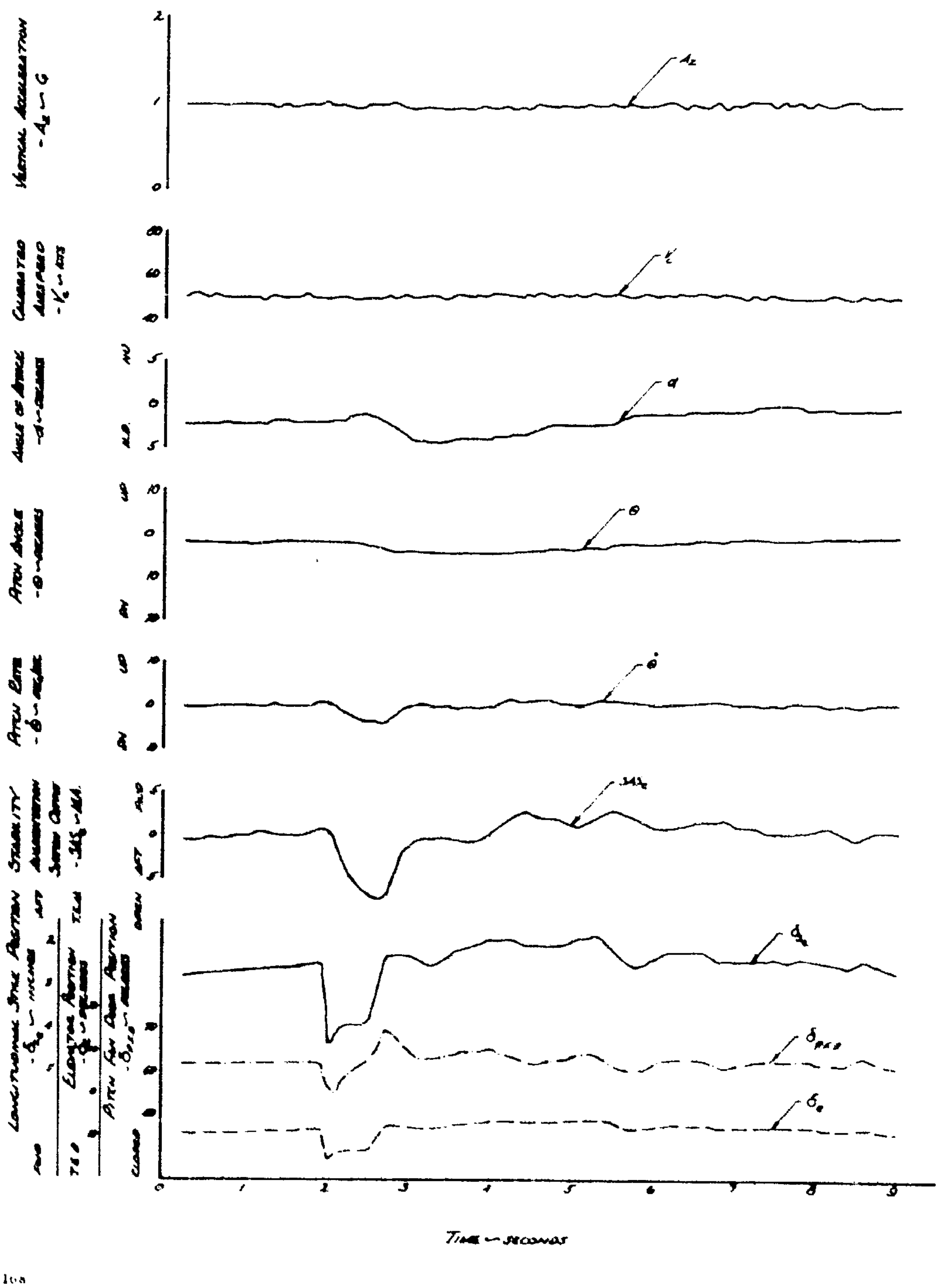


FIGURE No. 54
DYNAMIC LONGITUDINAL STABILITY
XV-5A USA S/N 62-4506
FAN MODE

FLT. CONDITION: LEVEL FLT.
TRIM AIRSPEED = 59 KCAS
TRIM ANGLE OF ATTACK = 1.5°
COLLECTIVE POS = 100 %
HOR. STABILIZER POS. = 21°

AVG PRESSURE ALT = 4850 FT
AVG G.W. = 10060 LB
AVG C.G. LOC = 240.9 IN (MID)
SAS CONFIG = OPTIMUM
LANDING GEAR FIXED DOWN
WITH HEAT SHIELD INSTALLED

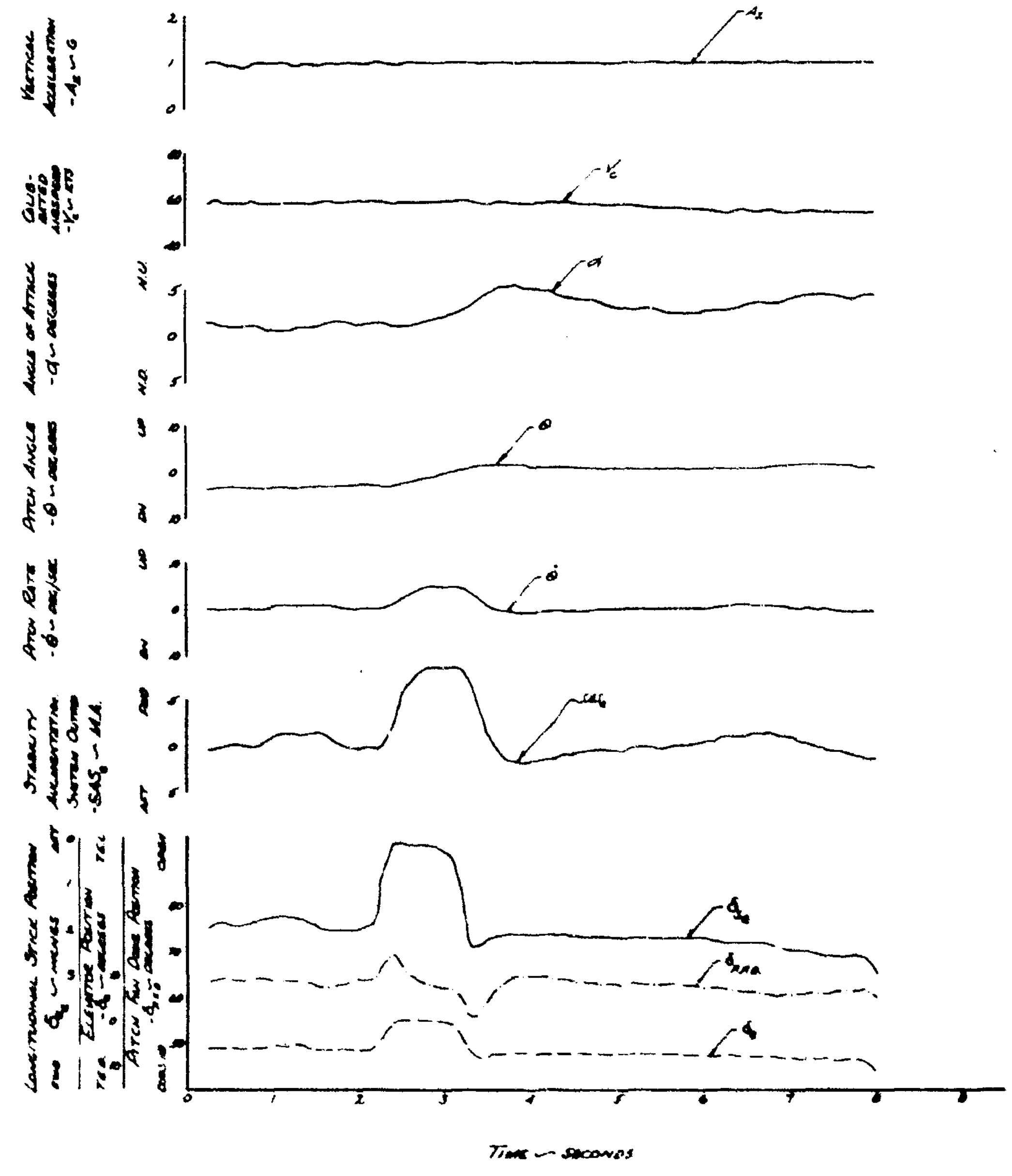


FIGURE No. 55

DYNAMIC LONGITUDINAL STABILITY

XV-5A USA S/N 62-4505

FAN MODE

FLT. CONDITION : LEVEL FLT.
TRIM AIRSPEED = 83 KCAS
TRIM ANGLE OF ATTACK = -1°
COLLECTIVE POS. = 100 %
HOR. STABILIZER POS. = 10°

AVG. PRESSURE ALT. = 3100 FT
AVG. G.W. = 9750 LB
AVG. C.G. LOC. = 240.8 IN (AFT)
SAS CONFIG. = OPTIMUM
LANDING GEAR FIXED DOWN
WITH HEAT SHIELD INSTALLED.

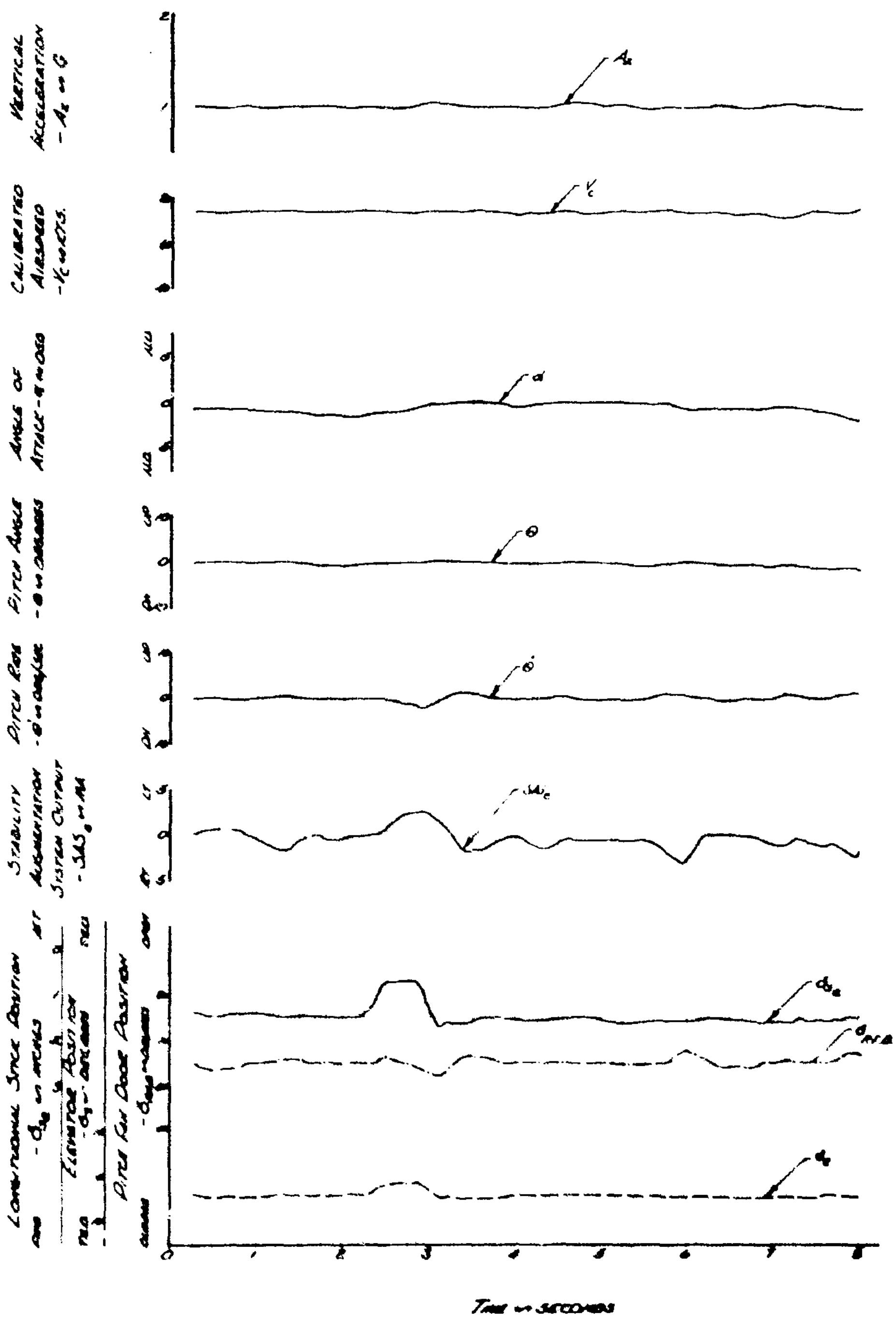


FIGURE NO. 56
DYNAMIC LATERAL-DIRECTIONAL STABILITY
XV-5A USA S/N 624505
FAN MODE

FLT. CONDITION: HOVER
AVG PRESSURE ALT. = 2310 FT.
COLLECTIVE POS. = 70% (UP)
HOR. STABILIZER POS. = 21° T.E.D.
AVG G.W. = 10006 LB
AVG C.G. LOC. = 241 IN.(MID)
SAS CONFIG. = OPTIMUM
WHEEL HT ABOVE GND = 15 FT.
LANDING GEAR FIXED DOWN
WITH HEAT SHIELD INSTALLED

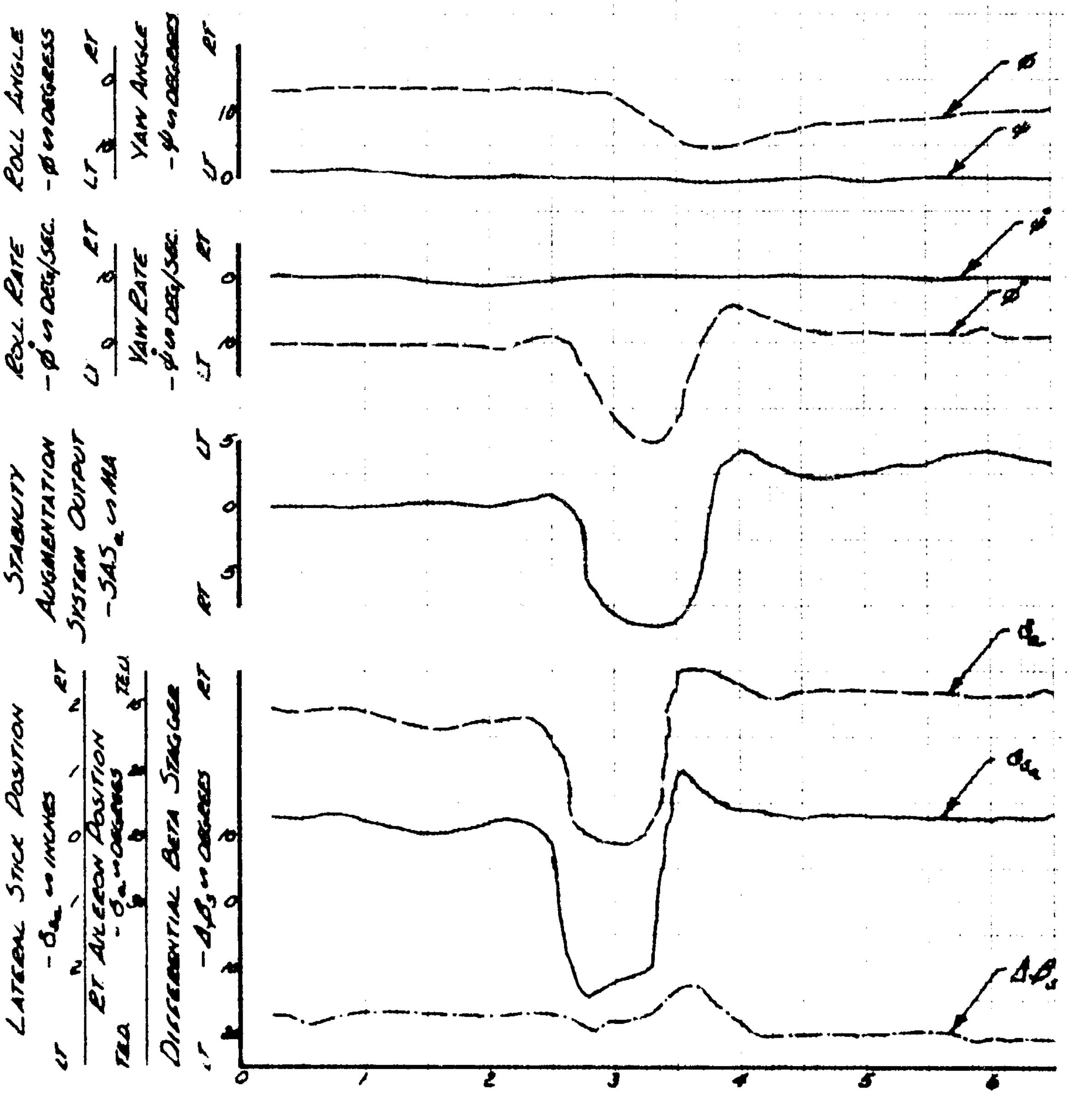


FIGURE No. 57
DYNAMIC LATERAL-DIRECTIONAL STABILITY
XV-5A USA S/N 624505
FAN MODE

FLT CONDITION : LEVEL FLT.	AVG PRESSURE ALT = 5680 FT
TRIM AIRSPEED = 30 KCAS	AVG G.W = 9960 LB
TRIM ANGLE OF ATTACK = 2.7°	AVG C.G. LOC = 240.1 IN (MID)
COLLECTIVE POS = 100% (UP)	SAS CONFIG = OPTIMUM
HOR. STABILIZER POS = 21° T.E.D.	LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.

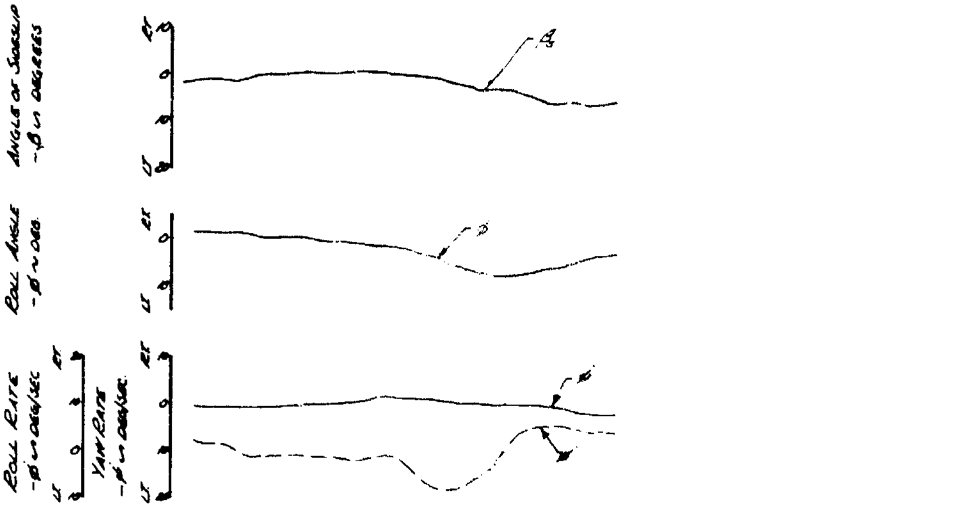


FIGURE No. 58
DYNAMIC DIRECTIONAL STABILITY
XV-5A USA S/N 62-4505
FAN MODE

FLT. CONDITION: HOVER
PRESSURE ALT = 2280 FT
COLLECTIVE POS = 30%
HOR. STABILIZER POS = 21°

AVG G.W. = 9966 LB
AVG C.G. LOC = 241.6 IN (MAC)
SAS CONFIG = OPTIMUM
WHEEL HT ABOVE GND = 25 FT.

LANDING GEAR F... D DOWN WITH
HEAT SHIELD ... ALLED

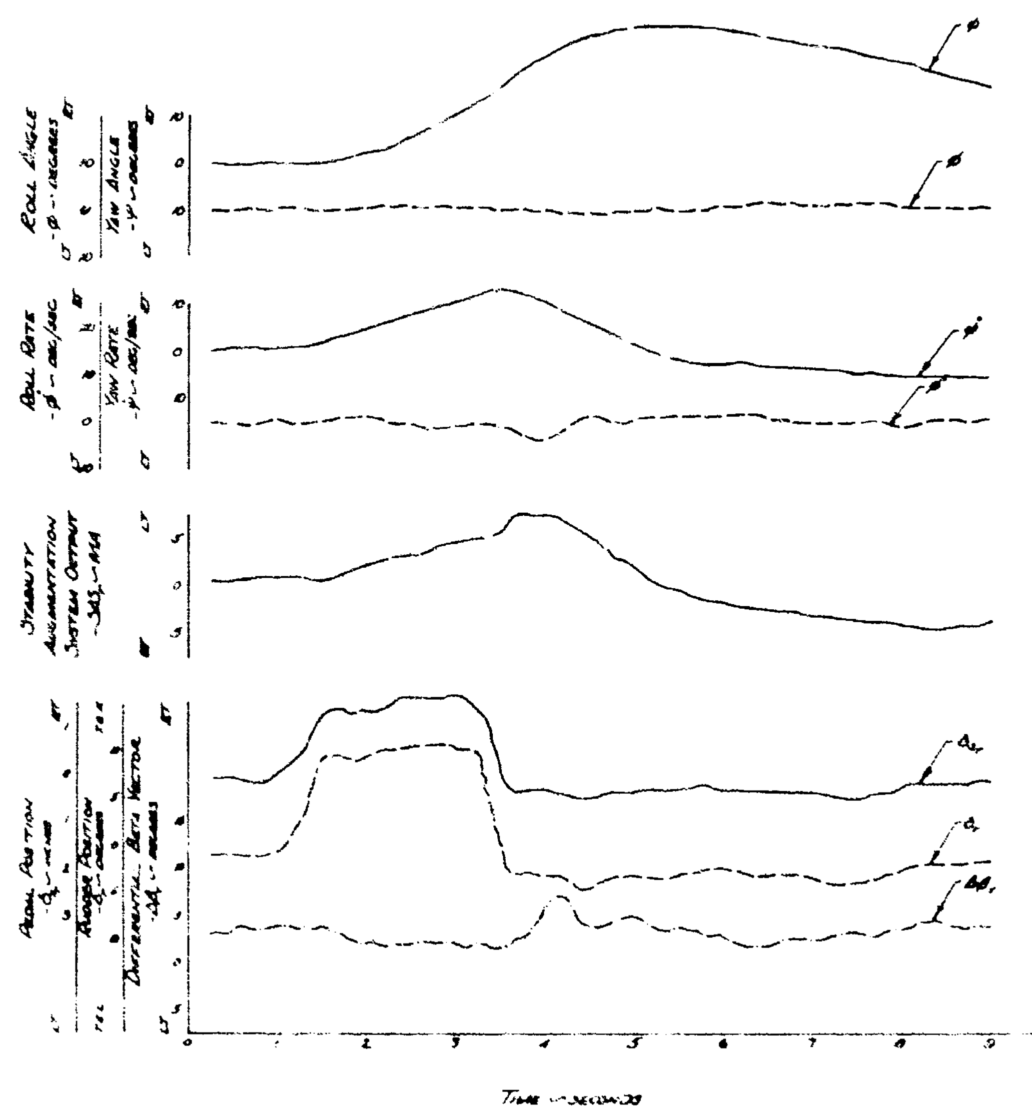
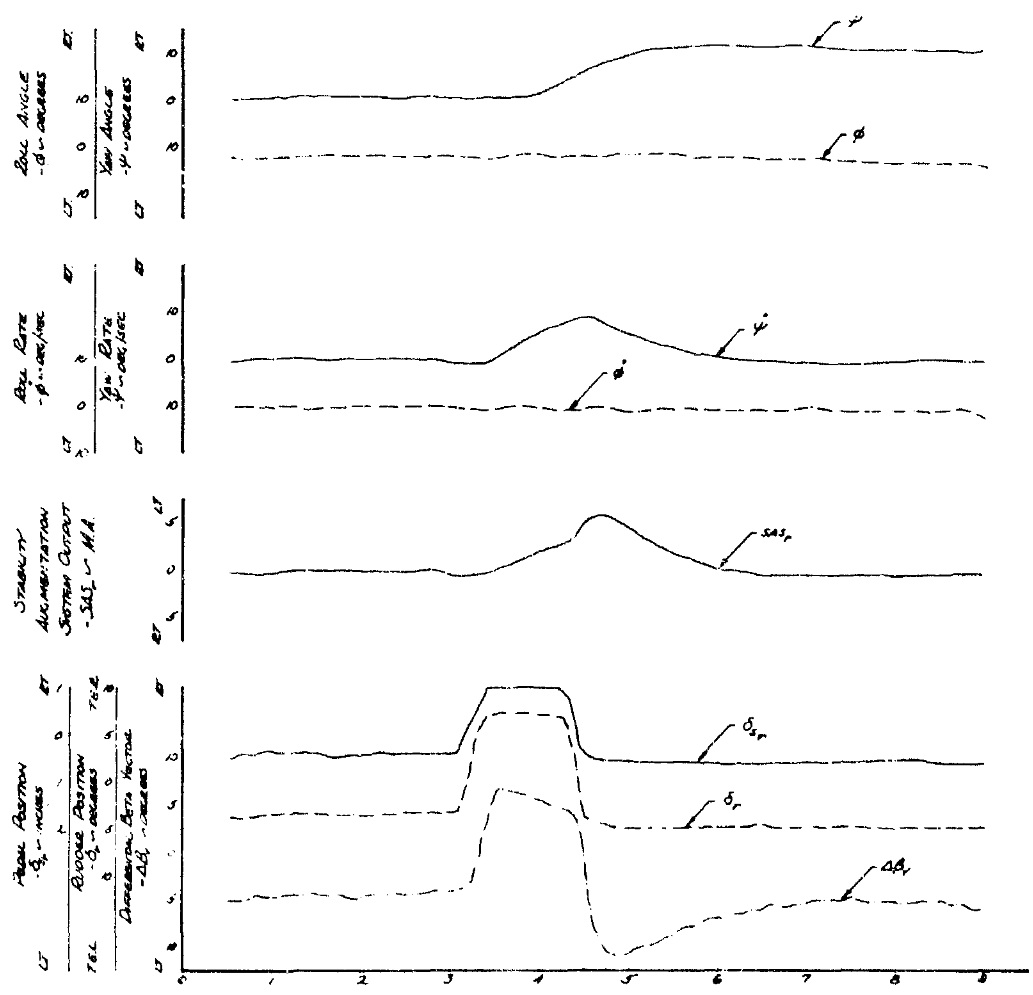


FIGURE NO. 59
DYNAMIC DIRECTIONAL STABILITY
XV-5A USA S/N 62-4505
FAN MODE

FLT CONDITION : HOVER
AVG PRESSURE ALT = 2258 FT
COLLECTIVE POS = 70%
HOR STABILIZER POS = 21°
AVG G.W = 9368 LB.
AVG C.G. LOC = 281.8 IN (MID)
SAS CONFIG = OPTIMUM
WHEEL HT ABOVE ... 10 - 25 FT
LANDING GEAR FIXED DOWN WITH
HEAT SHIELD INSTALLED.



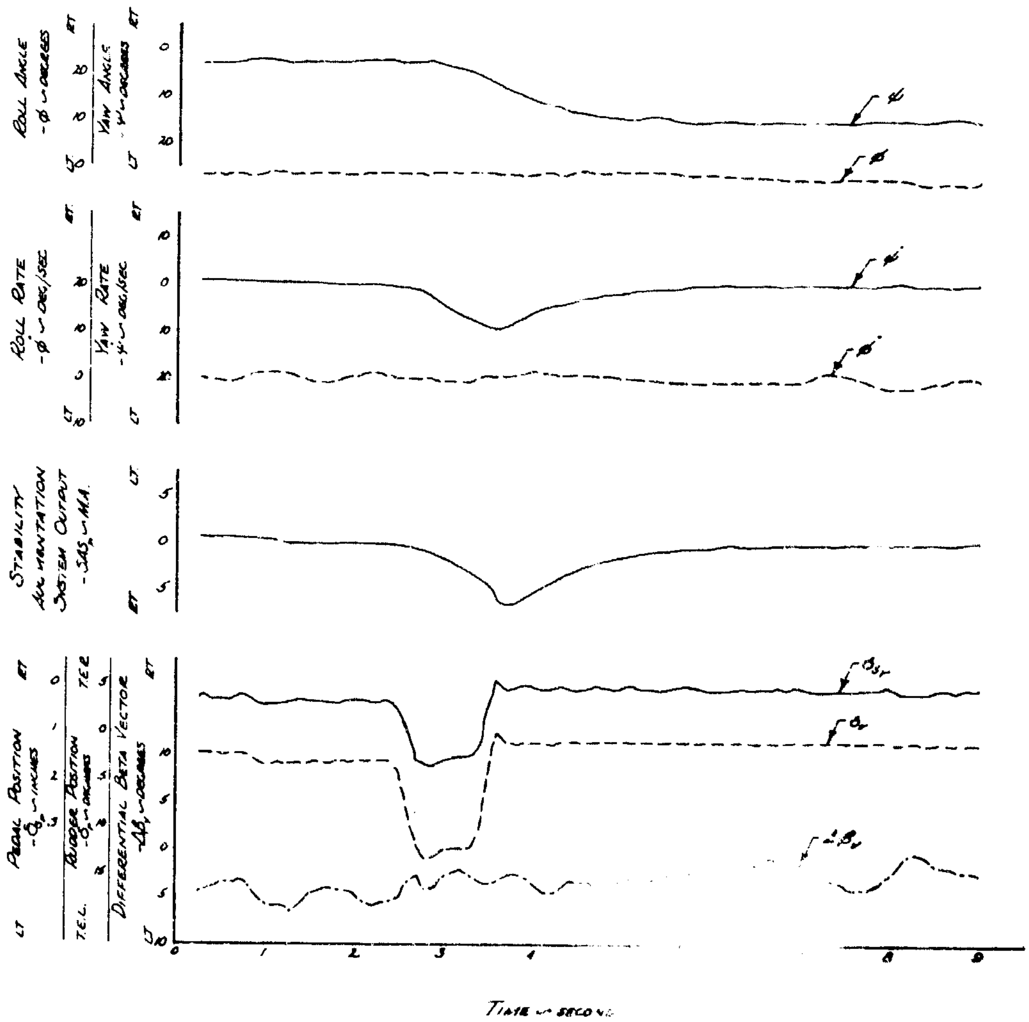
TIME ~ SECONDS

FIGURE No. 60
DYNAMIC DIRECTIONAL STABILITY
XV-5A USA S/N 62-4505
FAN MODE

FLT CONDITION : HOVER
PRESSURE ALT = 2240 FT
COLLECTIVE POS = 70 %
HOR. STABILIZER POS. = 21°

AVG G.W = 9970 LB.
AVG C.G LOC = 241.0 IN(MID)
SAS CONFIG = OPTIMUM
WHEEL HT ABOVE GND = 2.5 FT

LANDING GEAR FIXED DOWN WITH
HEAT SHIELD INSTALLED.

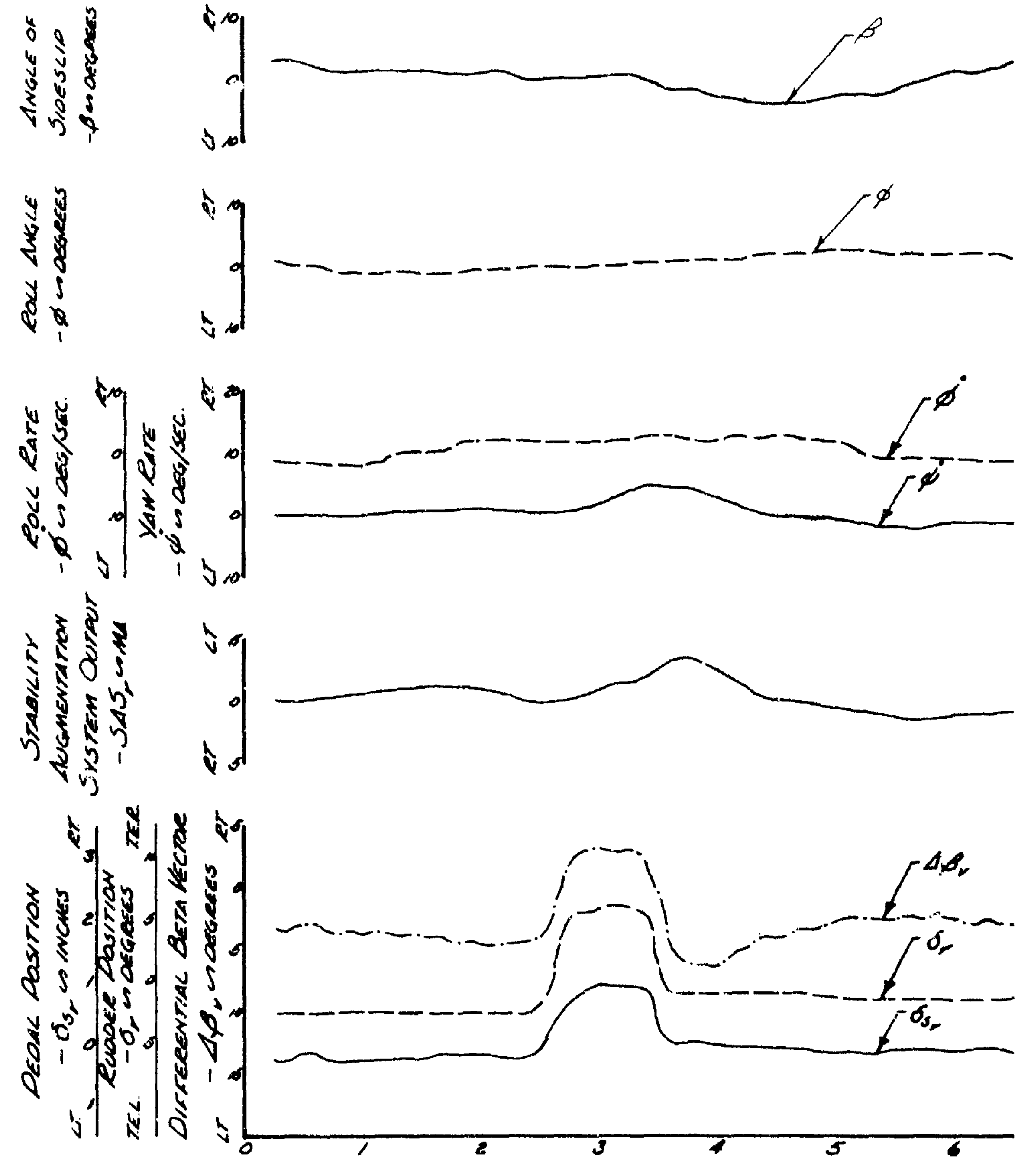


TIME ~ SECONDS

FIGURE NO. 61
DYNAMIC DIRECTIONAL STABILITY
XV-5A USA S/N 62 4505
FAN MODE

FLT. CONDITION : LEVEL FLT.
TRIM AIRSPEED = 30 KCAS
TRIM ANGLE OF ATTACK = -.8°
COLLECTIVE POS. = 100 % (UP)
HOR. STABILIZER POS. = 21° T.E.D.

AVG PRESSURE ALT. = 5600 FT.
AVG G.W. = 9940 LB
AVG C.G. = 240.7 IN (MID)
SAS CONFIG. = OPTIMUM
LANDING GEAR FIXED DOWN
WITH HEAT SHIELD INSTALLED.



TIME ~ SECONDS

FIGURE No. 62
DYNAMIC DIRECTIONAL STABILITY
XV-5A USA S/N 624505
FAN MODE

FLT. CONDITION: LEVEL FLT.
TRIM AIRSPEED = 30 KCAS
TRIM ANGLE OF ATTACK = ~1.0°
COLLECTIVE POS. = 100% (UP)
HOR. STABILIZER POS. = 21° TED.

AVG PRESSURE ALT = 5520 FT
AVG G.W. = 8566 LB
AVG C.G. LOC = 240.7 IN (MAC)
SAS CONFIG = OPTIMUM
LANDING GEAR FIXED DOWN
WITH HEAT SHIELD INSTALLED

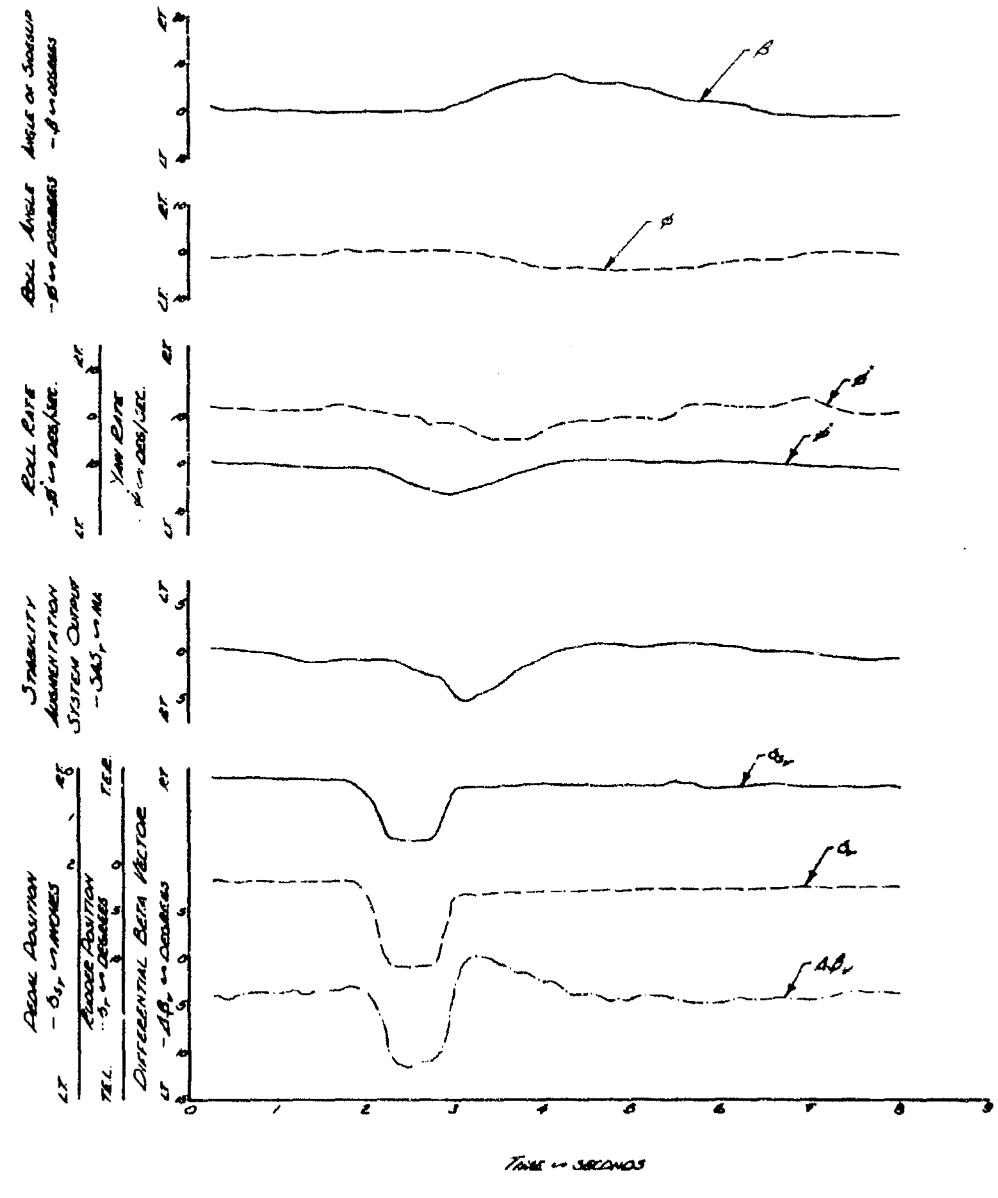


FIGURE No. 63
DYNAMIC DIRECTIONAL STABILITY
XV-5A USA S/N 62-4505
FAN MODE

FLT. CONDITION : LEVEL FLT
TRIM AIRSPEED = 45 KCAS
TRIM ANGLE OF ATTACK = -1.5°
COLLECTIVE POS = 100 % (UP)
HOR. STABILIZER POS = 19.3° TED

AVG PRESSURE ALT = 3200 FT
AVG GW = 9940 LB
AVG CG LOC. = 240.6 IN (MID)
SAS CONFIG = OPTIMUM
LANDING GEAR FIXED DOWN
WITH HEAT SHIELD INSTALLED

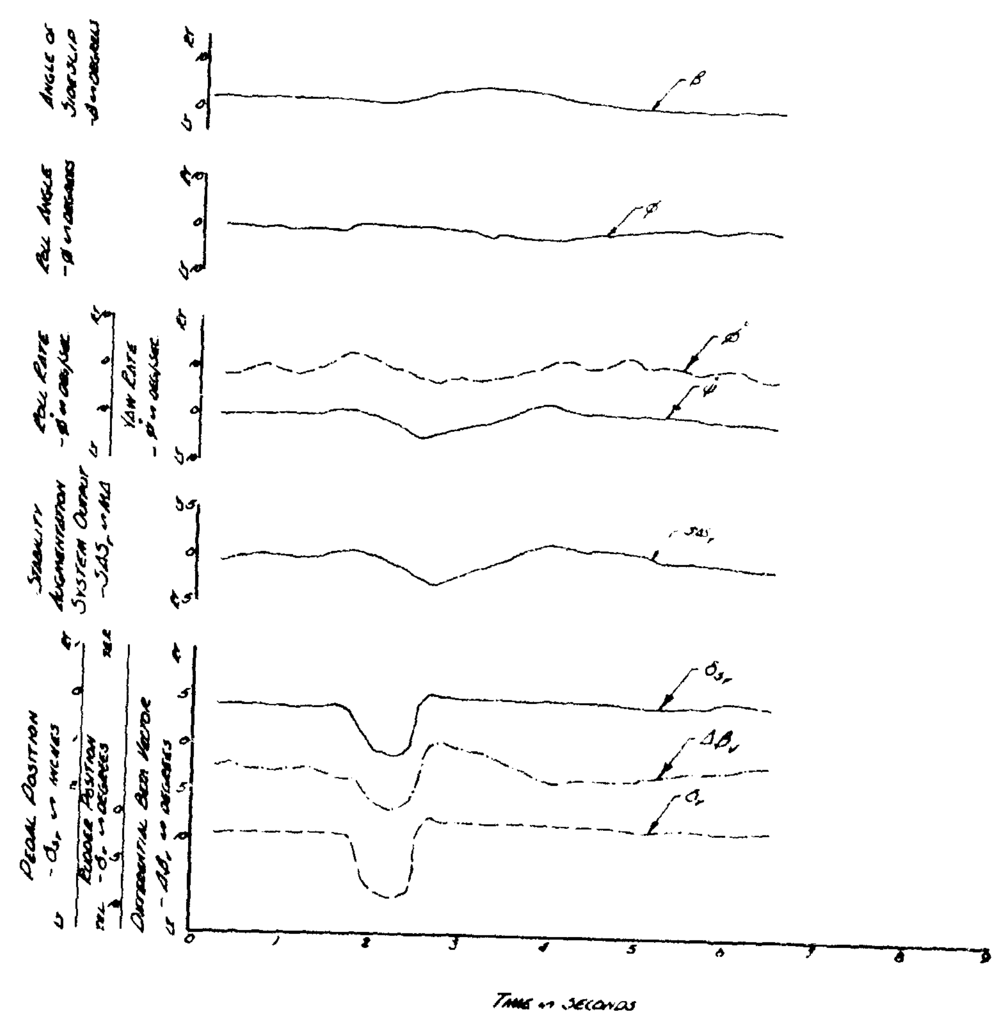


FIGURE No. 64.
DYNAMIC DIRECTIONAL STABILITY
XV-5A USA %62-4505
FAN MODE

FLT CONDITION : LEVEL FLT.
TRIM AIRSPEED = 52. KCAS
TRIM ANGLE OF ATTACK = -6°
COLLECTIVE POS = 100 % (UP)
HOR. STABILIZER POS. = 21° T.E.D.

AVG. PRESSURE ALT = 4780 FT.
AVG. G.W. = 9760 LB
AVG C.G. LOC = 241.2 IN(MID)
SAS CONFIG. = OPTIMUM
LANDING GEAR FIXED DOWN
WITH HEAT SHIELD INSTALLED.

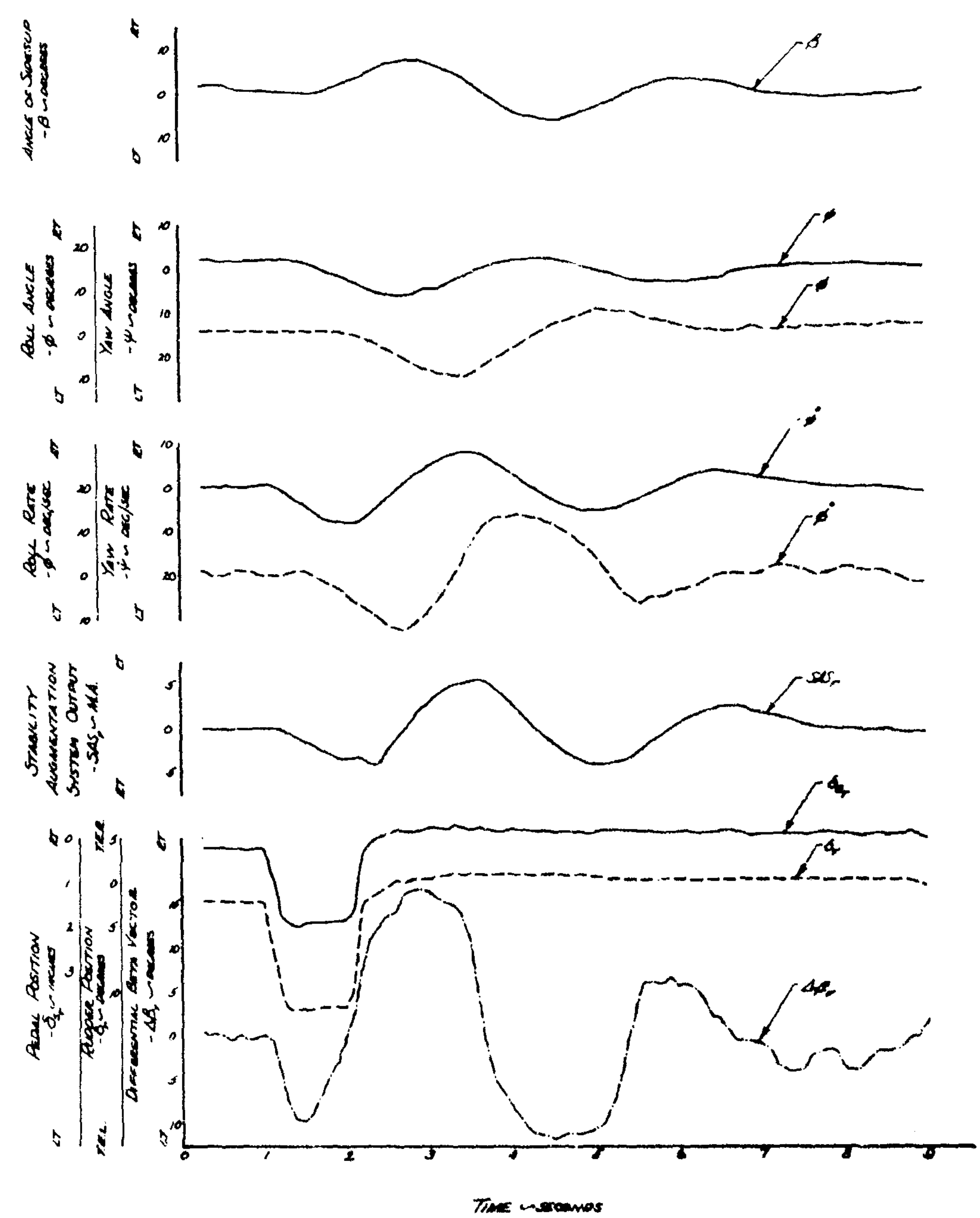


FIGURE No. 65

DYNAMIC DIRECTIONAL STABILITY

XV-5A USA S/N 624505

FAN MODE

FLT CONDITION : LEVEL FLT
TRIM AIRSPEED = 73 KCAS
TRIM ANGLE OF ATTACK = 2.0°
COLLECTIVE POS = 100% (UP)
HOR. STABILIZER POS. = 21° TED

AVG PRESSURE ALT = 4750 FT
AVG G.W. = 9690 LB
AVG C.G. = 240.9 IN (MID)
SAS CONFIG: OPTIMUM
LANDING GEAR FIXED DOWN
WITH HEAT SHIELD INSTALLED

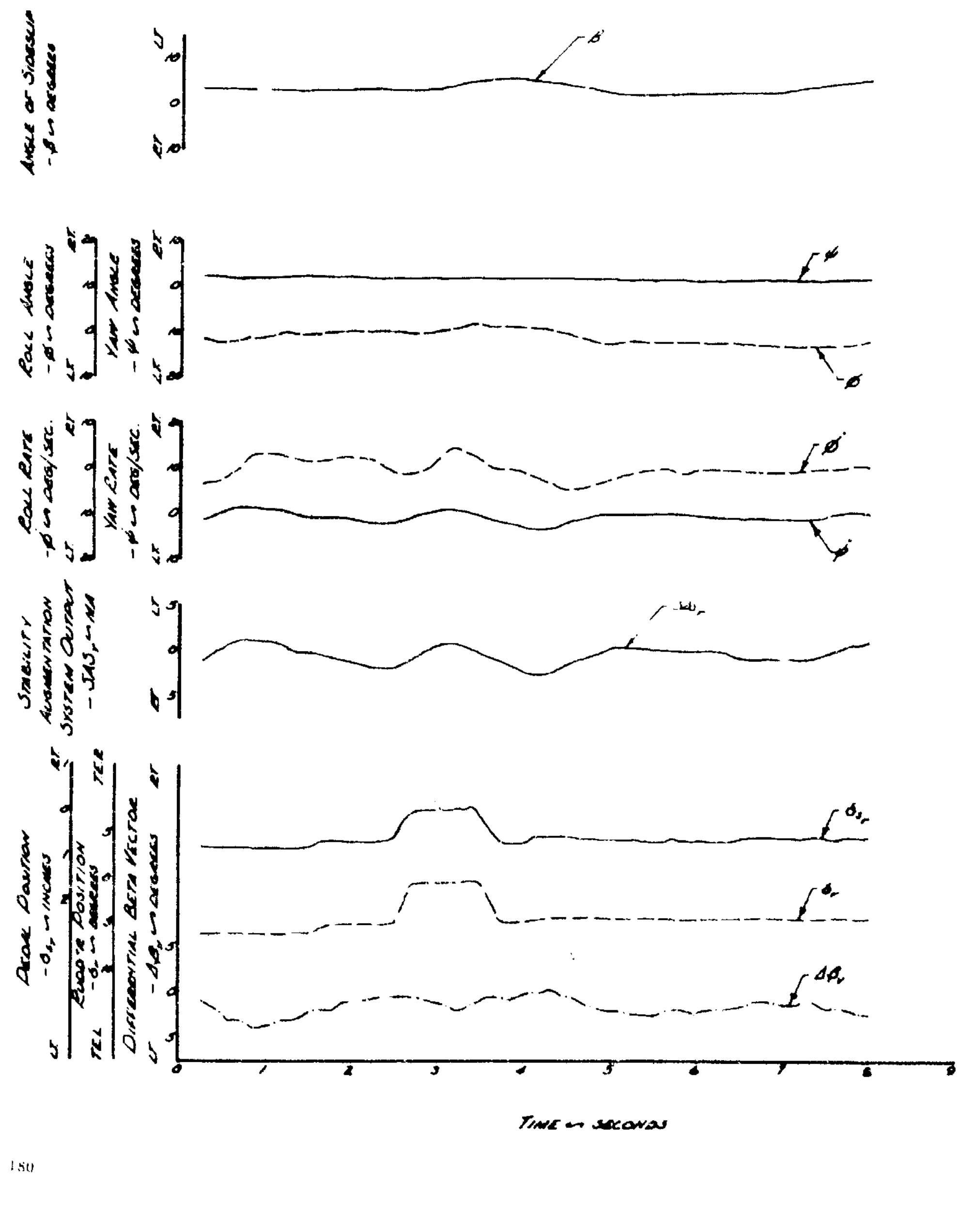


FIGURE No. 66
LONGITUDINAL CONTROLLABILITY
XV-5A USA S/N 62-4505
SAS ON PRIMARY
FAN MODE

SYM FWD	SYM AFT	AVG. ALT. $-H_p$ ~ FT	AVG G.W ~ LB	AVG. CG. LOC ~ IN.	COLL STICK POS ~ % (UP) δ_c	FLIGHT CONDITION
△	○	2330	9990	240.6 (MID)	30	HOVER (25 FT WHEEL HT)
□	◇	2310	9890	240.8 (MID)	70	HOVER (25 FT WHEEL HT)
○	◇	4650	9750	241.0 (MID)	100	LEVEL FLIGHT

LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.
POINTS DERIVED FROM FIGURE NO. 67 THROUGH 72 SECTION 3, APPENDIX I.

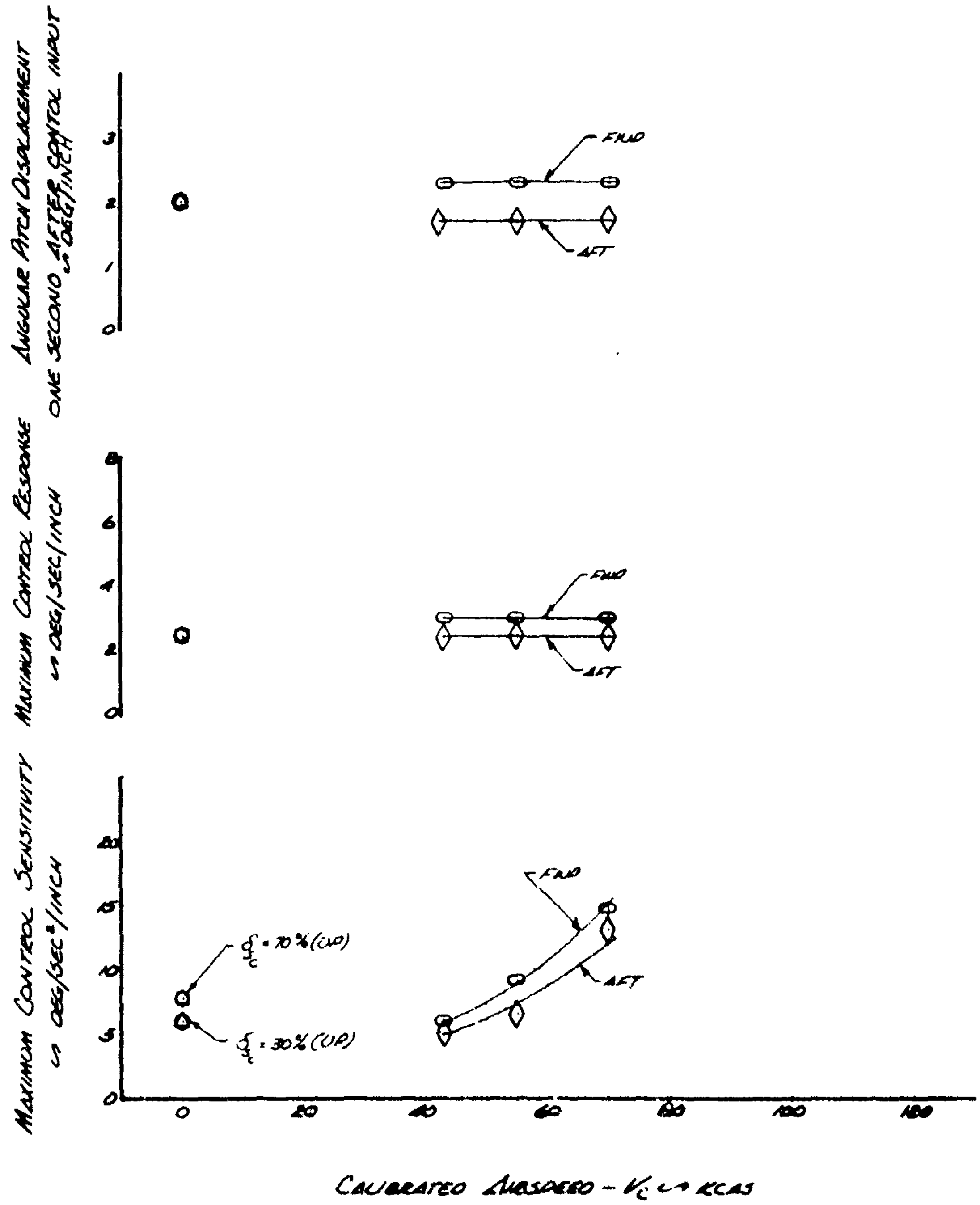


FIGURE NO. 67
LONGITUDINAL CONTROL SENSITIVITY
XV-5A USA S/N 62-4505
SAS ON PRIMARY
FAN MODE

SYM	AIRSPEED ~ KCAS	AVG ALT H_p ~ FT	AVG G.W. ~ LB	AVG C.G. ~ IN	δ_{s_c} ~ %	CONFIGURATION
○	0	2330	9090	240.6 (MID)	30 (UP)	HOVER
□	0	2310	9890	240.8 (MID)	70 (UP)	HOVER

WHEEL HEIGHT ABOVE GROUND = 25 FT
LANDING GEAR FIXED DOWN WITH
HEAT SHIELD INSTALLED.

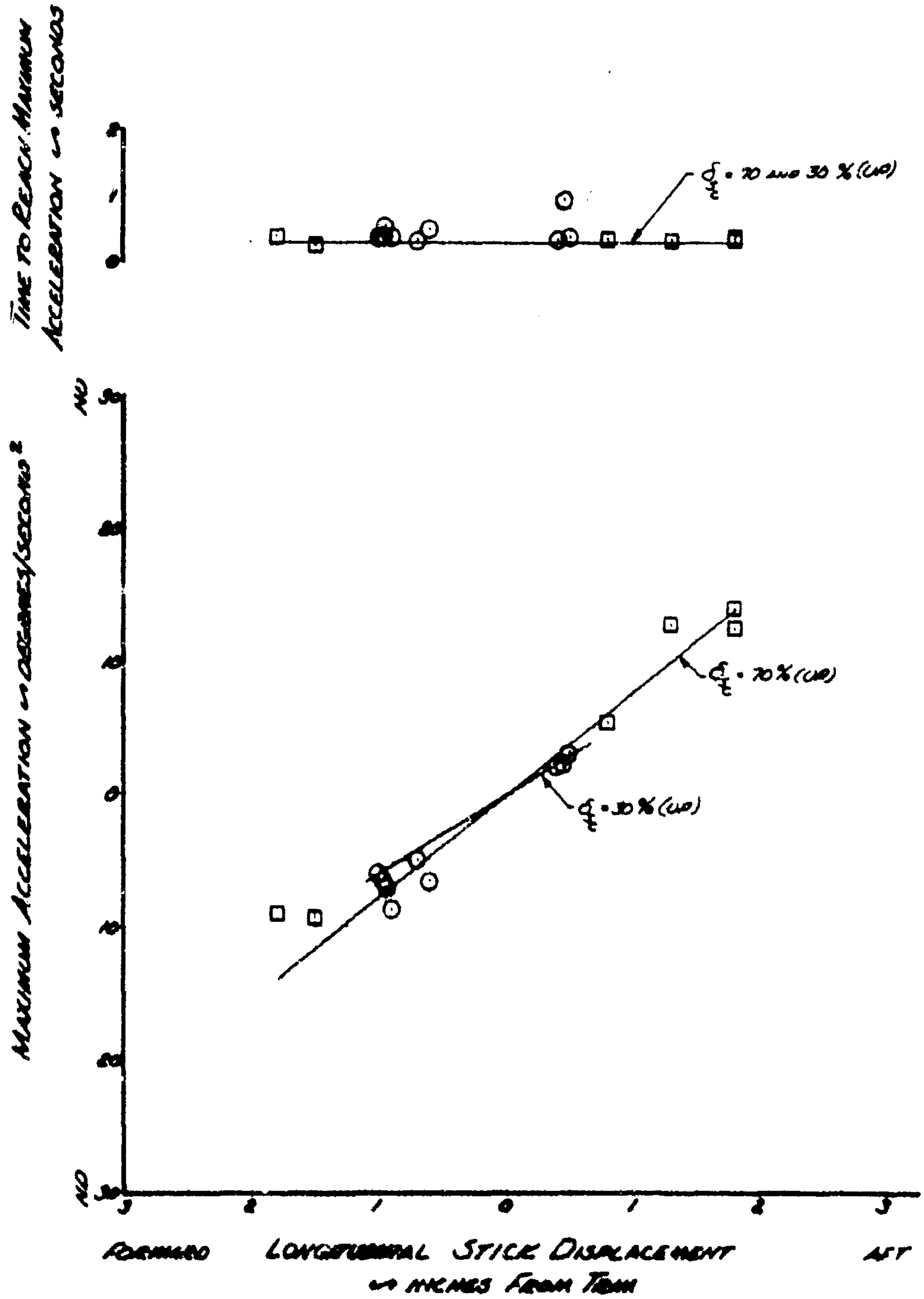


FIGURE No. 68
LONGITUDINAL CONTROL SENSITIVITY
XV-5A USA S/N 62-4505
SAS ON PRIMARY
FAN MODE

SYM	AIRSPEED V_c ~ KCAS	AVG ALT H_p ~ FT	AVG G.W. ~ LB	AVG C.G. ~ IN.	δ_{s_c} ~% (UP)	CONFIGURATION
◇	43	5100	9820	241.0(MID)	100	LEVEL FLIGHT
△	55	5260	9720	241.2(MID)	100	LEVEL FLIGHT
○	70	4230	9710	241.0(MID)	100	LEVEL FLIGHT

LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.

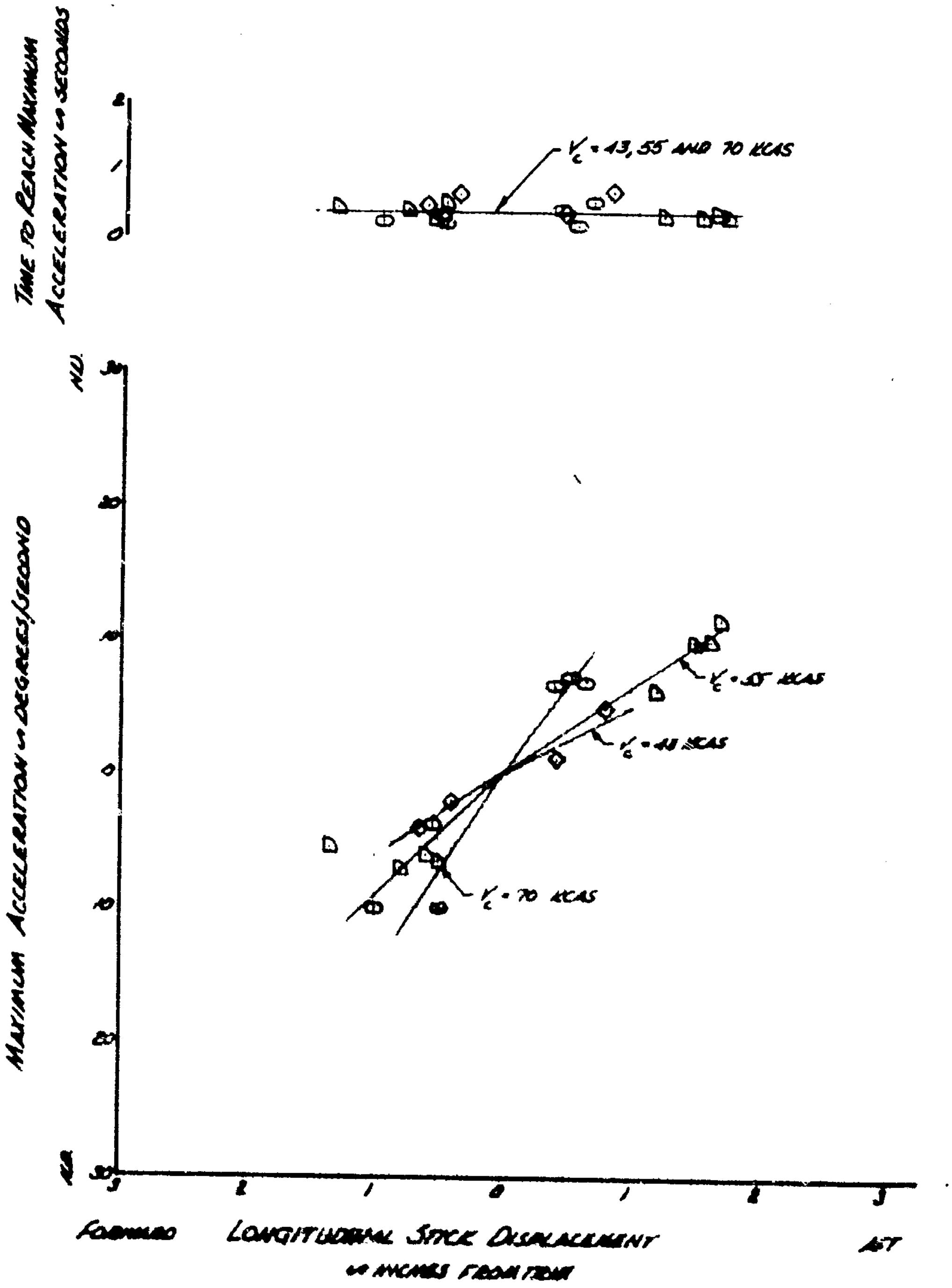


FIGURE NO. 69

LONGITUDINAL CONTROL RESPONSE

XV-5A USA S/N 62 4505

SAS ON PRIMARY

FAN MODE

SYM	AIRSPEED ~ KCAS	AVG ALT ~ FT	AVG G.W. ~ LB	AVG C.G. ~ IN	δ_{s_c} ~ % (UP)	CONFIGURATION
○	0	2280	9970	241.0 (MID)	30	HOVER
□	0	2310	9890	240.8 (MID)	70	HOVER

WHEEL HEIGHT ABOVE GROUND = 25 FT.
LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.

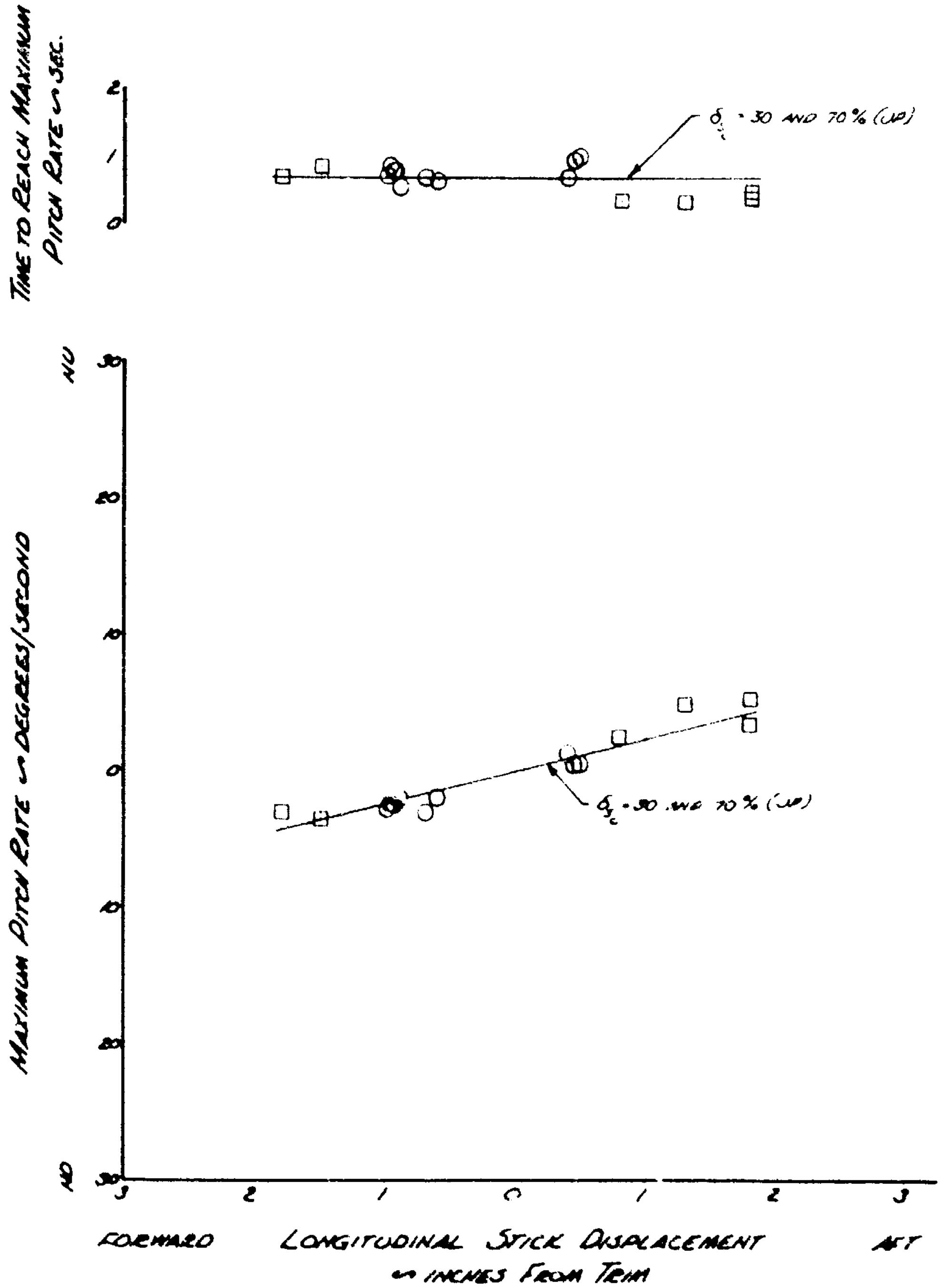


FIGURE No. 70

LONGITUDINAL CONTROL RESPONSE

XV-5A USA No. 62-4505

SAS ON PRIMARY

FAN MODE

SYM	AIRSPEED $-V_c$ ~ KTS	AVG. ALT $-H_p$ ~ FT	AVG. G.W. ~ LB	AVG. C.G. LOC ~ IN.	COLL STICK POS-δ_c ~ % (UP)	CONFIG.
◇	43	5100	9820	241.0(10)	100	LEVEL FLT.
D	55	5260	9720	241.2(MID)	100	LEVEL FLT
O	70	[illegible]230	9710	241.0(MID)	100	LEVEL FLT

LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.

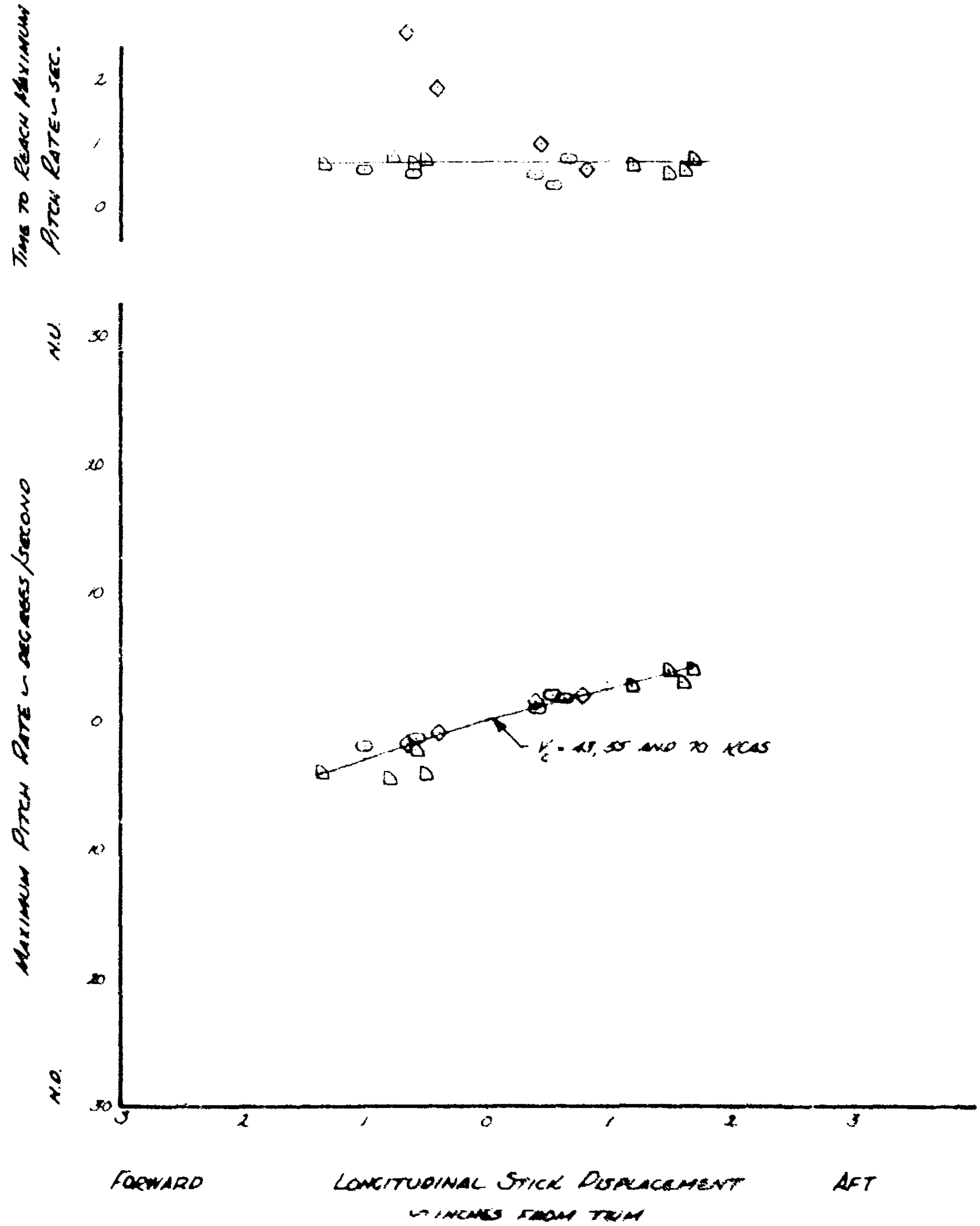


FIGURE No. 71

ANGULAR PITCH DISPLACEMENT

XV-5A USA S/N 62-4505

SAS ON PRIMARY

FAN MODE

SYM	AIRSPEED $-V_c$ ~ KCAS	AVG. ALT $-H_p$ ~ FT	AVG. G.W. ~ LB	AVG. C.G LOC ~ IN.	COLL STICK POS $-\delta_c$ ~ % CLIP	CONFIG
○	0	2280	9970	241.0(MID)	30	HOVER
□	0	2310	9890	240.8(MID)	70	HOVER

WHEEL HEIGHT ABOVE GROUND = 25 FT.
LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.

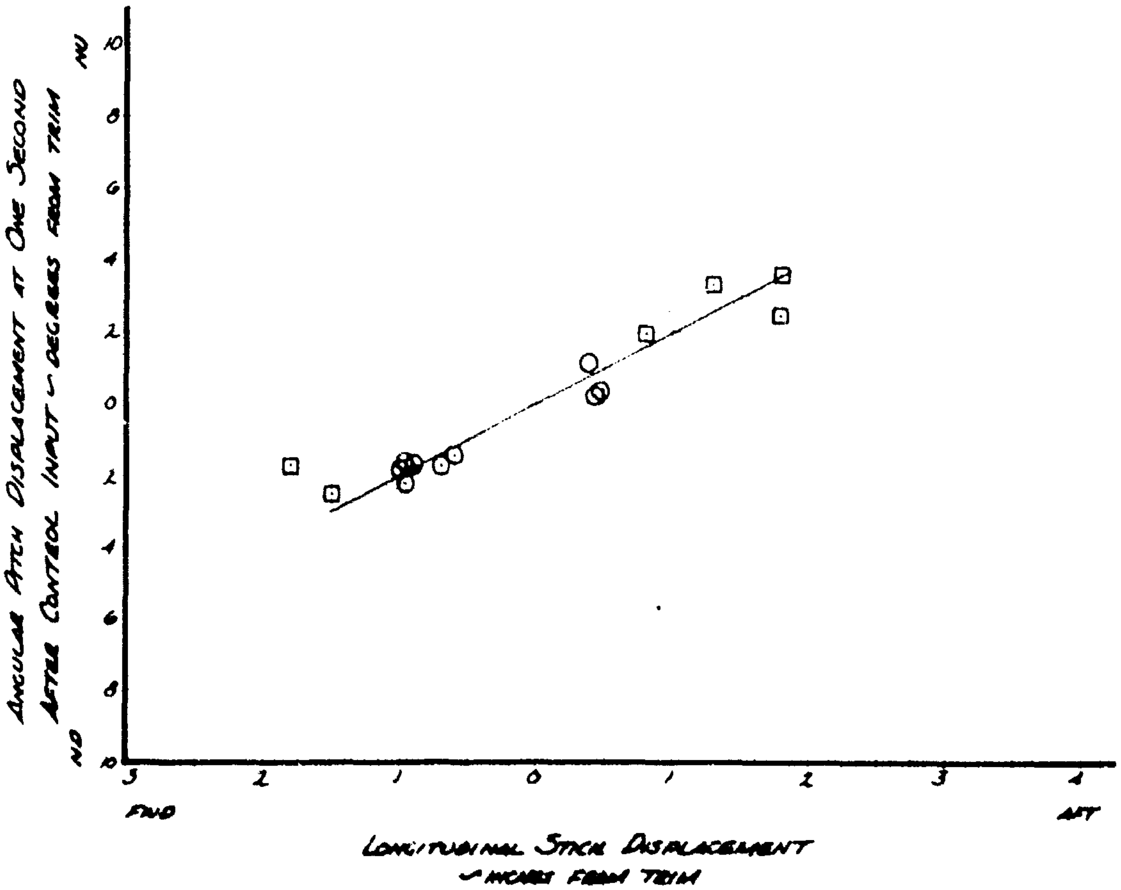


FIGURE No. 72

ANGULAR PITCH DISPLACEMENT

XV-5A USA S/N 62-4505

SAS ON PRIMARY

FAN MODE

SYM	AIRSPEED – V_c ~ KCAS	AVG. ALT. – H_p ~ FT	AVG. G.W. ~ LB	AVG CG ~ IN	COLL STICK POS – δ_c ~ % (UP)	CONFIG.
△	30	5360	9750	241.1 (MID)	100	LEVEL FLT.
◇	45	5180	9770	241.1 (MID)	100	LEVEL FLT.
D	55	5020	9970	241.2 (MID)	100	LEVEL FLT.
O	70	3120	9750	240.8 (MID)	100	LEVEL FLT.

LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.

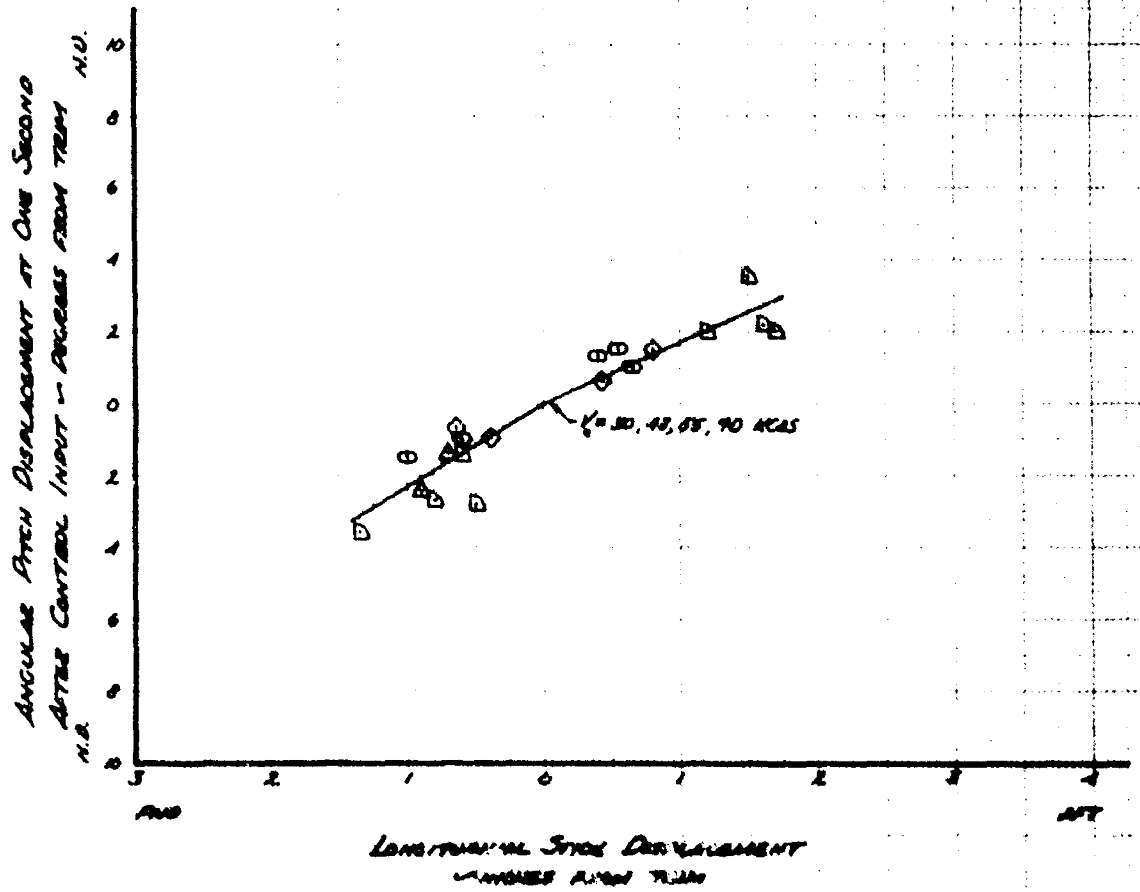


FIGURE No. 73
LATERAL CONTROLLABILITY
XV-5A USA S/N 62 4505
SAS ON PRIMARY
FAN MODE

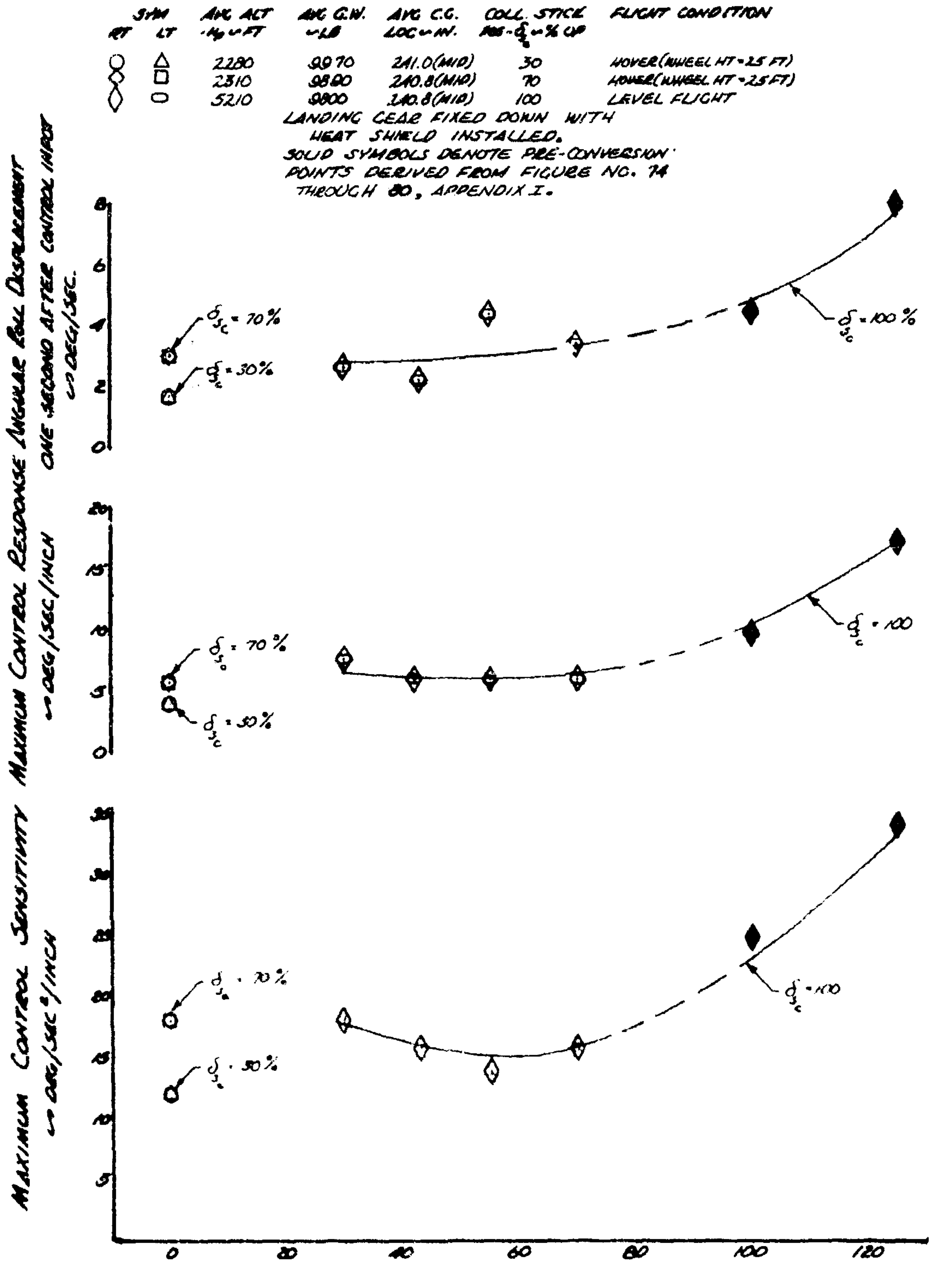


FIGURE No. 74
LATERAL CONTROL SENSITIVITY
XV-5A USA S/N 624505
SAS ON PRIMARY
FAN MODE

SYM	AIRSPEED ~ KCAS	AVG ALT H_p ~ FT	AVG G.W. ~ LB	AVG C.G. ~ IN	δ_{s_c} ~ % (UP)	CONFIGURATION
○	0	2320	10010	240.0 (MID)	30	HOVER
□	0	2330	10120	241.1 (MID)	70	HOVER

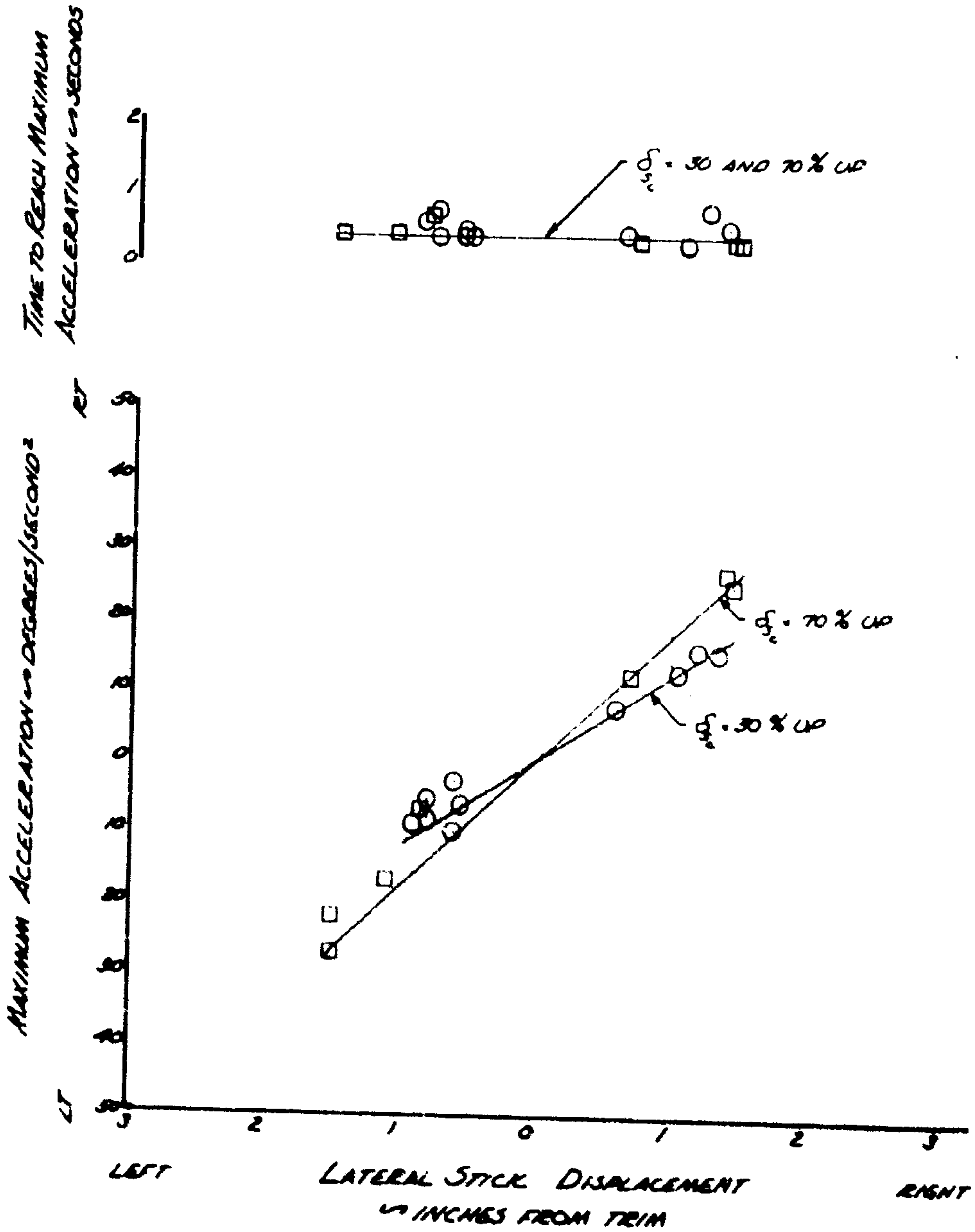


FIGURE No. 75
LATERAL CONTROL SENSITIVITY
XV-5A USA S/N 62-4505
SAS ON PRIMARY

SYM	AIRSPEED V_c ~ KCAS	AVG ALT H_p ~ FT	AVG G.W. ~ LB	AVG C.G ~ IN	δ_s ~ % (UP)	CONFIGURATION
△	30	5640	9930	240.7(MID)	100	FAN MODE(LEVEL FLT)
◇	43	5230	9780	241.1(MID)	100	FAN MODE(LEVEL FLT)
D	55	5710	9750	241.2(MID)	100	FAN MODE(LEVEL FLT)
○	70	3300	9610	241.1(MID)	100	FAN MODE(LEVEL FLT)
△	100	5120	10630	240.6(MID)	100	PRE-CONV.(LEVEL FLT)
○	125	5200	10410	240.8(MID)	100	PRE-CONV(LEVEL FLT)

LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.

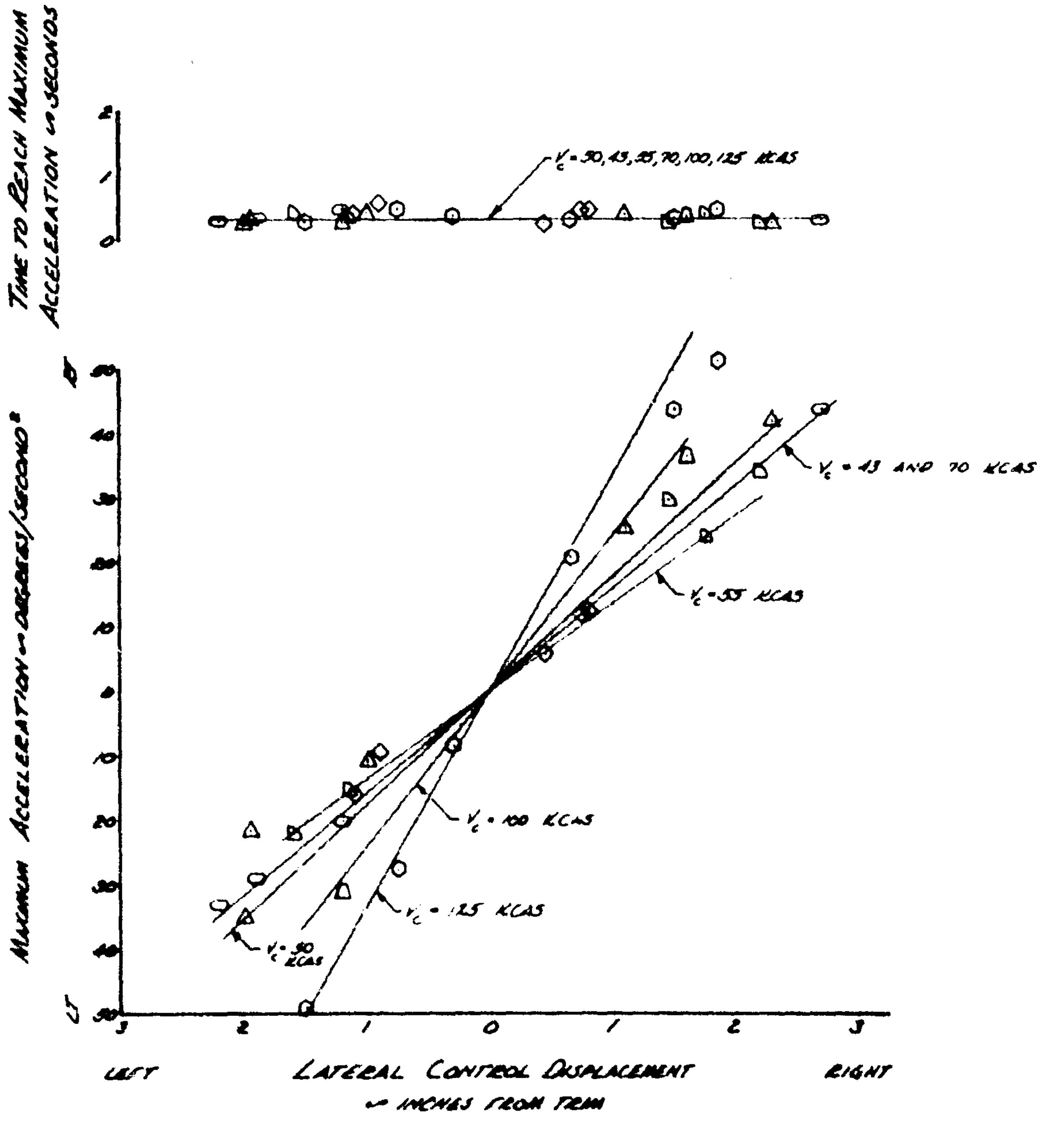


FIGURE No. 76
VARIATION IN LATERAL CONTROL SENSITIVITY
FOR DIFFERENT SAS GAIN VALUES

XV-5A USA S/N 62-4505

FAN MODE - HOVERING

SYM	AVG ALT. -H_p ~ FT	AVG. G.W. ~ LB.	AVG. CG. ~ IN	COLL STICK POS-δ_c ~ %(UP)	SAS GAIN ~ %
○	2320	10010	240.0(MID)	30	100 (OPTIMUM)
□	2320	10570	239.7(MID)	30	50
◇	2320	10200	239.5(MID)	30	25
△	2320	10090	239.4(MID)	30	0 (SAS OFF)

WHEEL HEIGHT ABOVE GROUND = 25 FT.
LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.

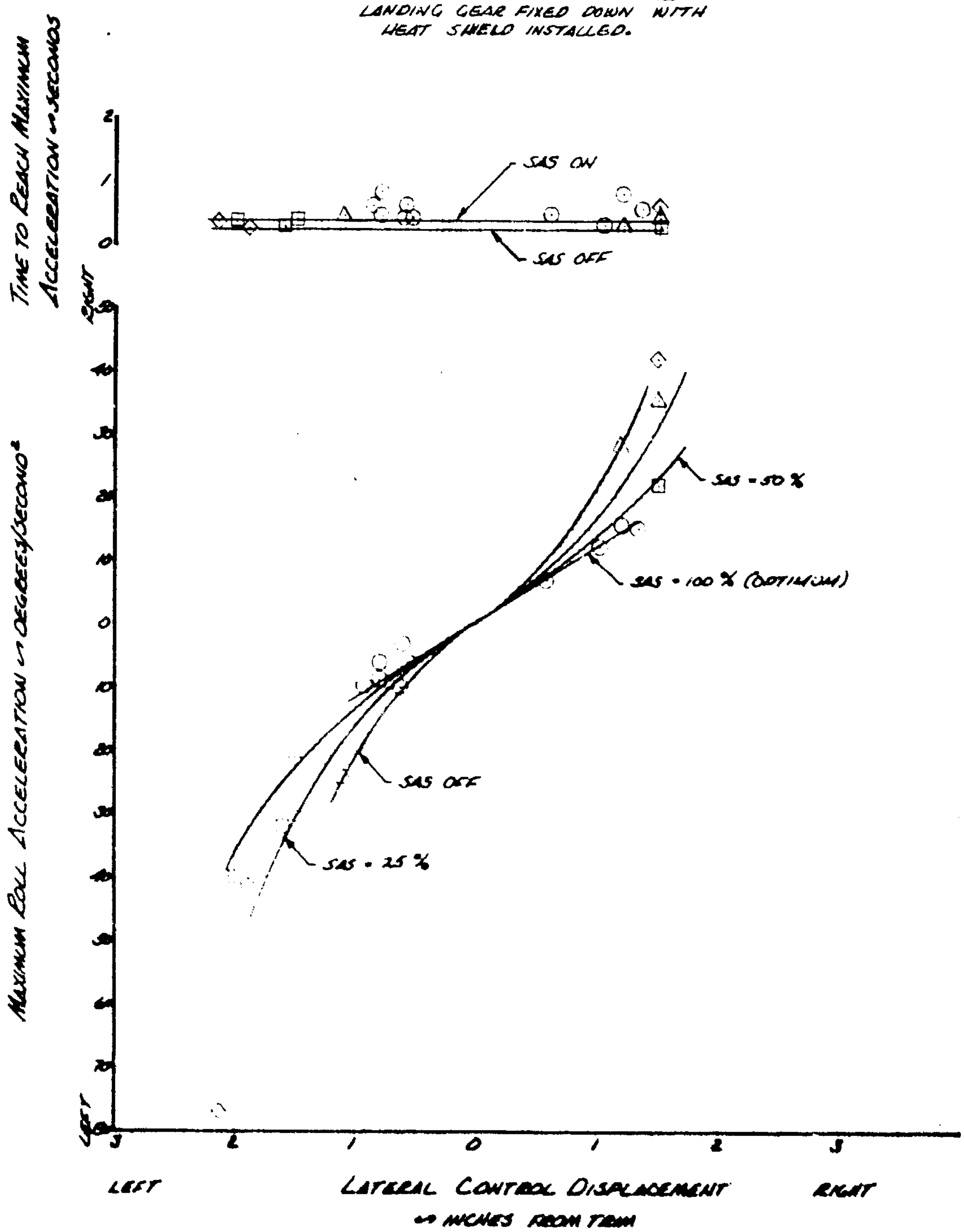


FIGURE NO. 77
LATERAL CONTROL RESPONSE
XV-5A USA S/N 624505
SAS ON PRIMARY
FAN MODE

SYM	AIRSPEED V_c ~ KCAS	AVG ALT H_p ~ FT	AVG G.W. ~ LB	AVG C.G ~ IN	δ_{S_C} ~ % (UP)	CONFIGURATION
○	0	2280	9970	241.0(MID)	30	HOVER
□	0	2310	9890	240.8(MID)	70	HOVER

WHEEL HEIGHT ABOVE GROUND ≈ 25 FT
LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.

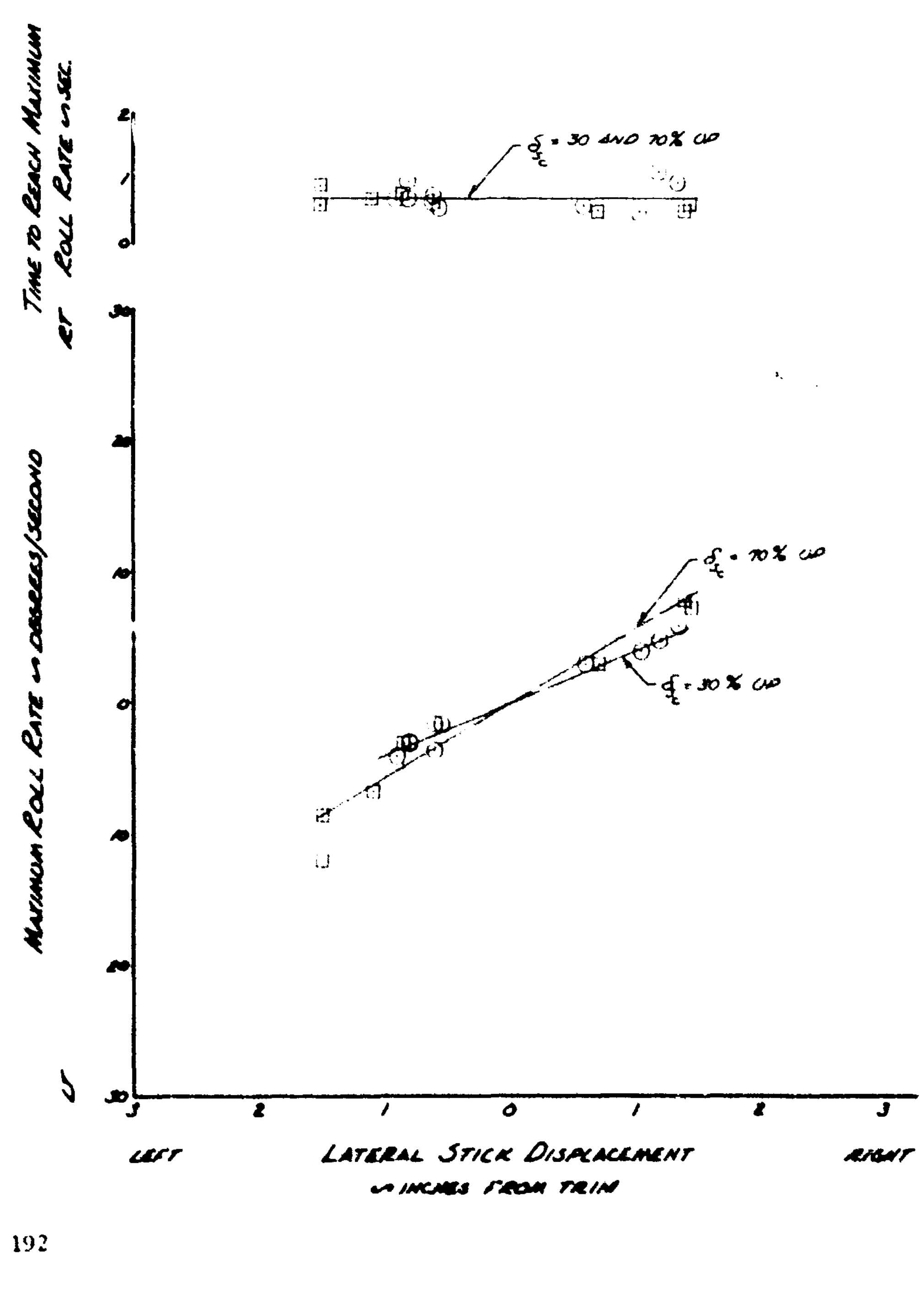


FIGURE NO. 78
LATERAL CONTROL RESPONSE
XV-5A USA S/N 62-4505
SAS ON PRIMARY

SYM	AIRSPEED V_c ~ KCAS	AVG ALT H_p ~ FT	AVG G.W. ~ LB	AVG C.G. ~ IN	δ_{s_c} ~ % UP	CONFIGURATION
△	30	5560	9680	240.7(MID)	100	FAN MODE (LEVEL FLT)
◇	43	5100	9820	241.1(MID)	100	FAN MODE (LEVEL FLT)
D	55	5260	9720	241.2(MID)	100	FAN MODE (LEVEL FLT)
O	70	4130	9710	241.0(MID)	100	FAN MODE (LEVEL FLT)
△	100	3350	9930	240.8(MID)	100	PRE-CONV (LEVEL FLT)
⬡	125	4840	9970	240.7(MID)	100	PRE-CONV. (LEVEL FLT)

LANDING GEAR FIXED DOWN WITH
HEAT SHIELD INSTALLED

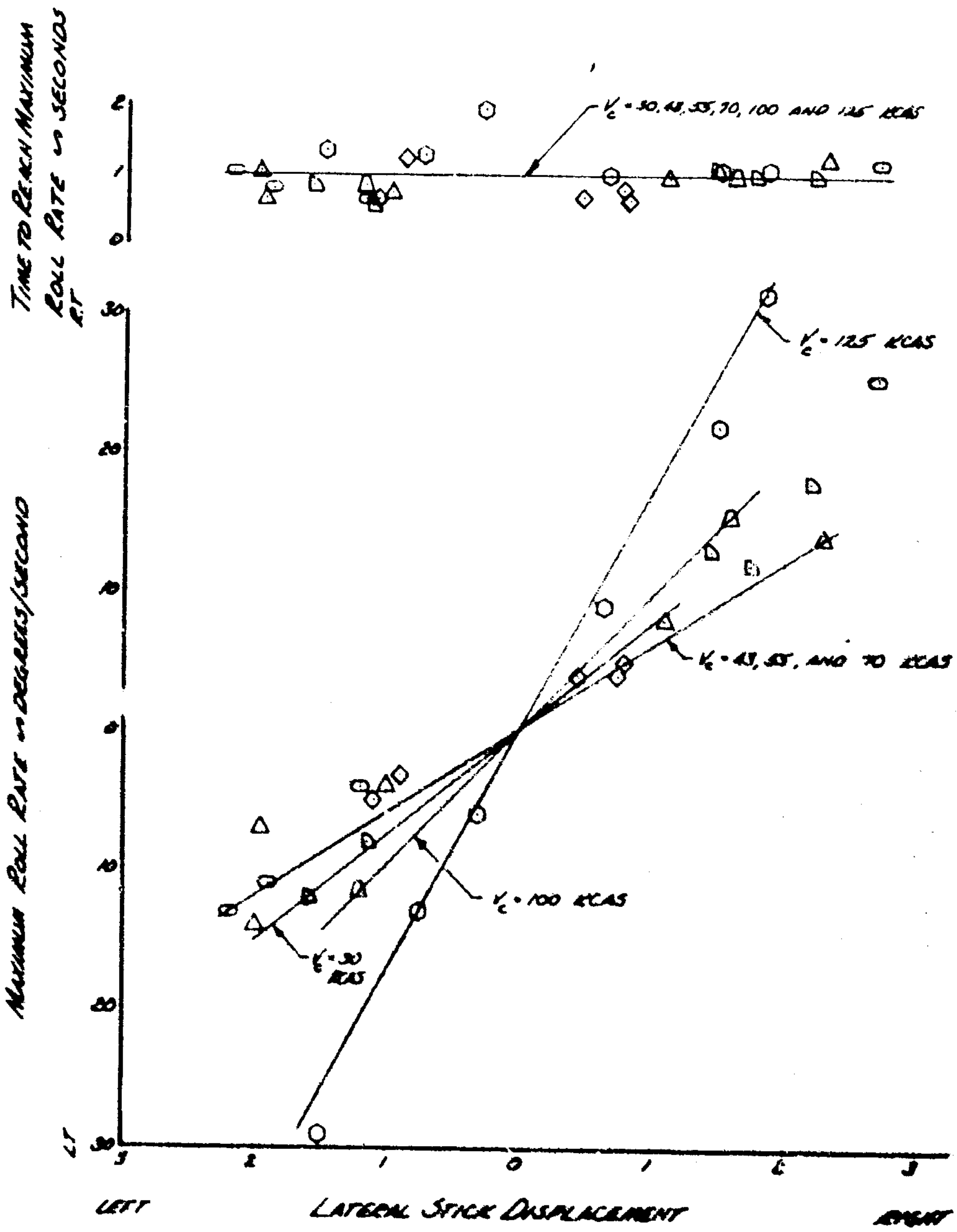


FIGURE No. 79
ANGULAR ROLL DISPLACEMENT
XV-5A USA S/N 62-4505
SAS ON PRIMARY
FAN MODE

SYM	AIRSPEED V_c ~ KCAS	AVG ALT. H_p ~ FT	AVG G.W. ~ LB	AVG C.G. ~ IN	δ_s ~ % (UP)	CONFIGURATION
○	0	2280	9970	241.0 (MID)	30	HOVER
□	0	2310	9890	240.8 (MID)	70	HOVER

WHEEL HEIGHT ABOVE GROUND = 25 FT
LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.

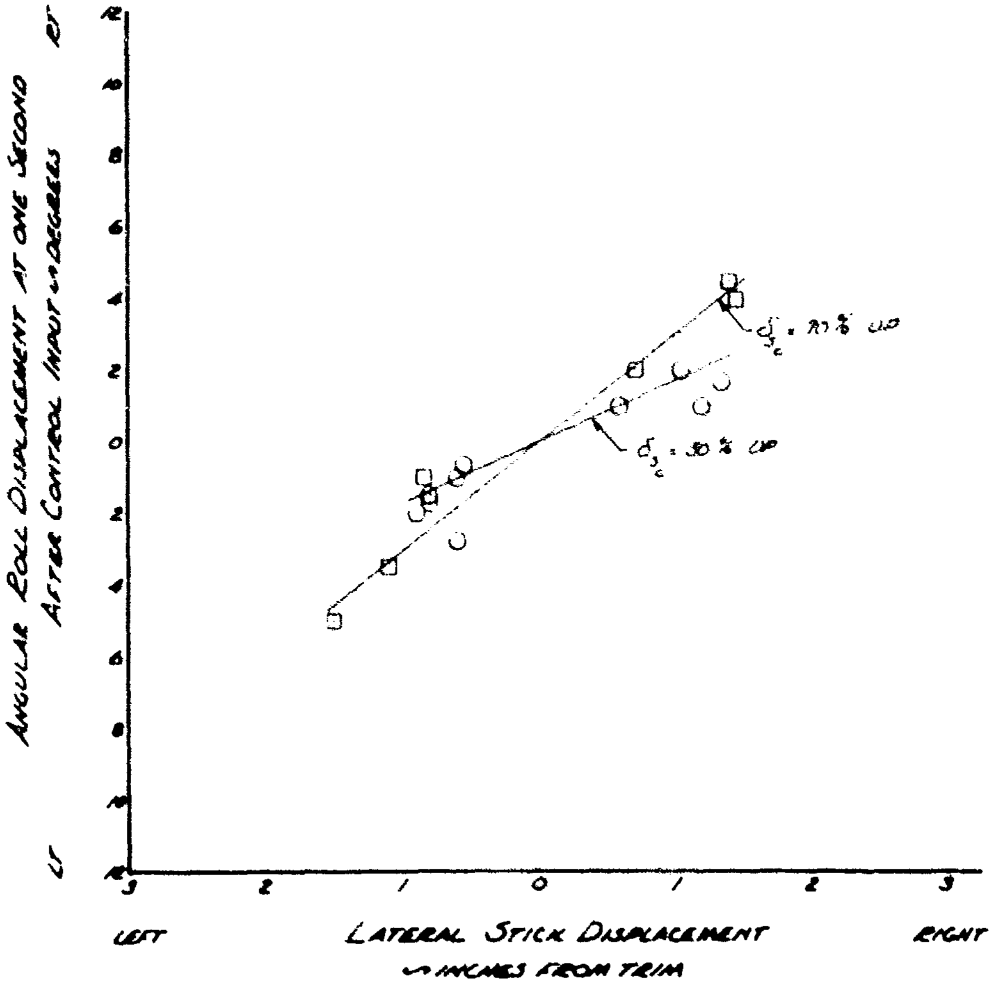


FIGURE No. 80
ANGULAR ROLL DISPLACEMENT
XV-5A USA S/N 624505
SAS ON PRIMARY

SYM	AIRSPEED V_c ~ KCAS	AVG ALT H_p ~ FT	AVG G.W. ~ LB	AVG C.G. ~ IN	δ_{sc} ~ % (UP)	CONFIGURATION
△	30	5560	9680	240.7(MID)	100	FAN MODE (LEVEL FLT)
◇	45	5100	9820	241.0(MID)	100	FAN MODE (LEVEL FLT)
□	55	5260	9720	241.2(MID)	100	FAN MODE (LEVEL FLT)
○	70	4250	9710	241.0(MID)	100	FAN MODE (LEVEL FLT)
△	100	5350	9930	240.8(MID)	100	PRE-CONV (LEVEL FLT)
⬡	125	4340	9970	240.7(MID)	100	PRE-CONV (LEVEL FLT)

LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.

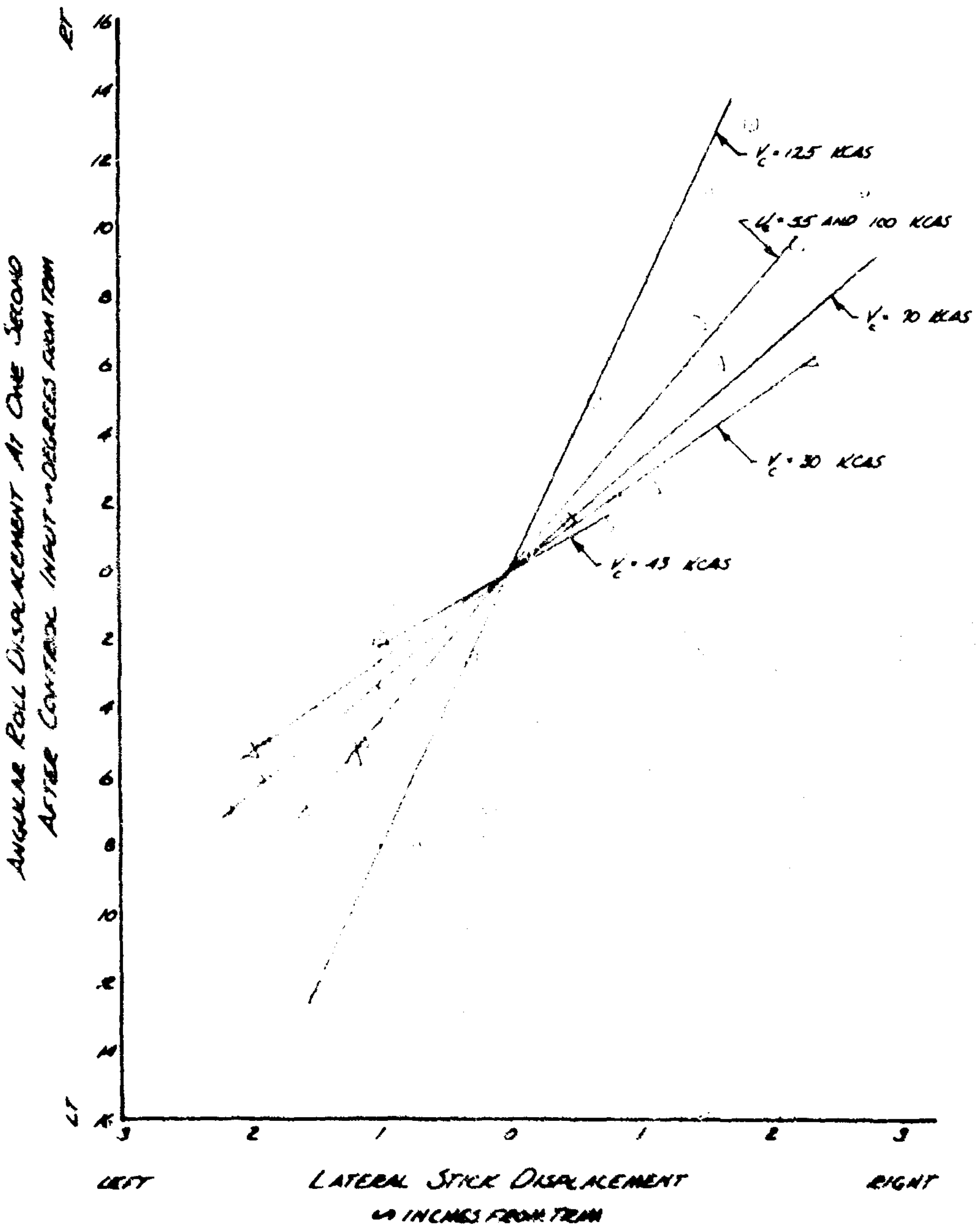


FIGURE NO. 81
DIRECTIONAL CONTROLLABILITY
XV-5A USA S/N 624505
SAS ON PRIMARY
FAN MODE

SYM LT.	SYM RT.	AVG ALT $-H_p$ ~ FT	AVG. G.W. ~ LB	AVG. C.G LOC ~ IN	COLL STICK POS - δ_c ~ % UP	FLT CONDITION
○	△	2280	9970	241.0 (MID)	30	HOVER
□	◇	2310	9890	240.8 (MID)	70	HOVER
◇	○	5010	9810	241.0 (MID)	100	LEVEL FLT.

LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.
SOLID SYMBOLS DENOTE PRE-CONVERSION CONFIGURATION.
POINTS DERIVED FROM FIGURE NO. 82 THROUGH 85, APPENDIX I.

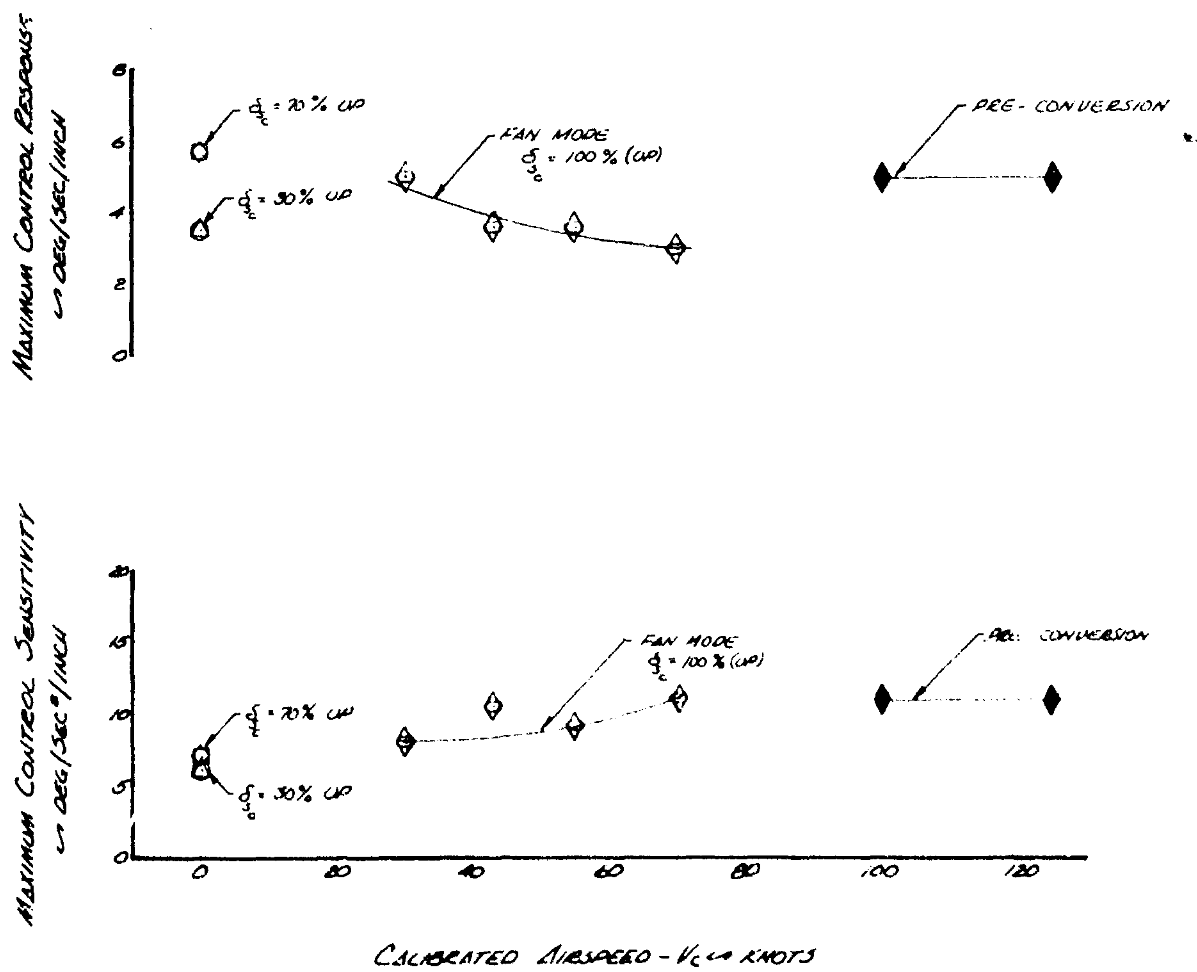


FIGURE No. 82
DIRECTIONAL CONTROL SENSITIVITY
XV-5A USA S/N 62-4505
SAS ON PRIMARY
FAN MODE

SYM	AIRSPEED V_c ~ KCAS	AVG ALT H_p ~ FT	AVG G.W. ~ LB	AVG C.G. ~ IN	δ_{sc} % UP	CONFIGURATION
○	0	2280	9970	241.0 (MID)	30	HOVER
□	0	2310	9890	240.8 (MID)	70	HOVER

WHEEL HEIGHT ABOVE GROUND = 25 FT.
LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.

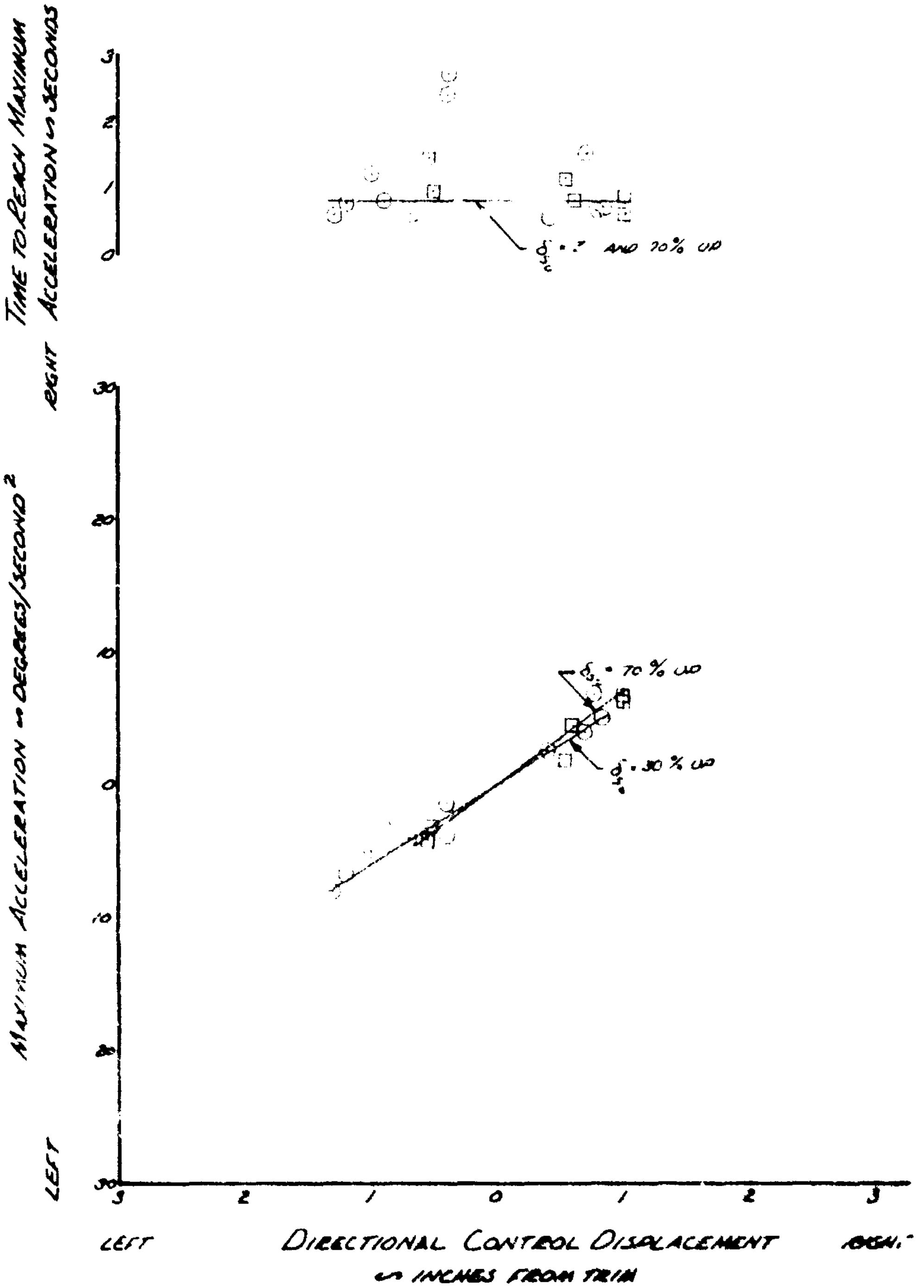


FIGURE No. 83

DIRECTIONAL CONTROL SENSITIVITY

XV-5A USA S/N 62-4505

SAS ON PRIMARY

SYM	AIRSPEED V_c ~ KCAS	AVG ALT H_p ~ FT.	AVG G.W. ~ LB	AVG C.G. LOC ~ IN	COLL STICK POS ~ % UP	CONFIGURATION
△	30	5560	9680	240.7 (MID)	100	FAN MODE (LEVEL FLT)
◇	43	5100	9820	241.0 (MID)	100	FAN MODE (LEVEL FLT)
▽	55	5260	9720	241.2 (MID)	100	FAN MODE (LEVEL FLT)
○	70	4230	9710	241.0 (MID)	100	FAN MODE (LEVEL FLT)
△	100	5350	9930	240.8 (MID)	100	PRE-CONV (LEVEL FLT)
⬡	125	4840	9970	240.7 (MID)	100	PRE-CONV (LEVEL FLT)

LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.

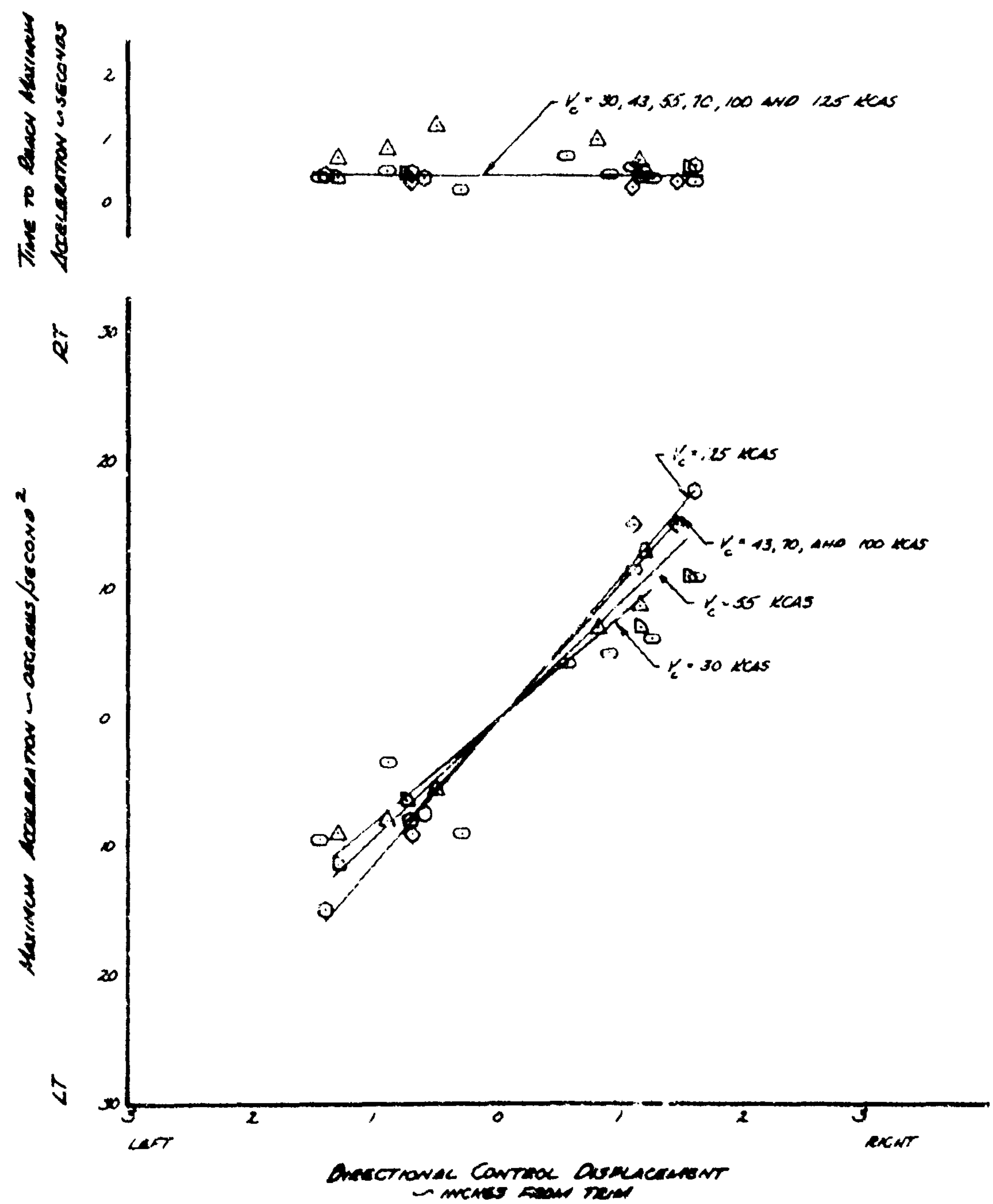


FIGURE No. 84
DIRECTIONAL CONTROL RESPONSE
XV-5A USA S/N 62-4505
SAS ON PRIMARY
FAN MODE

SYM	AIRSPEED ~ KCAS	AVG ALT. H_P ~ FT	AVG G.W. ~ LB	AVG C.G. ~ IN	δ_{S_C} % (UP)	CONFIGURATION
○	0	2280	9970	241.0 (MID)	30	HOVER
□	0	2310	9890	240.8 (MID)	70	HOVER

WHEEL HEIGHT ABOVE GROUND = 25 FT
LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.
RESPONSE AT 1.0 SECOND AFTER CONTROL DISPLACEMENT.

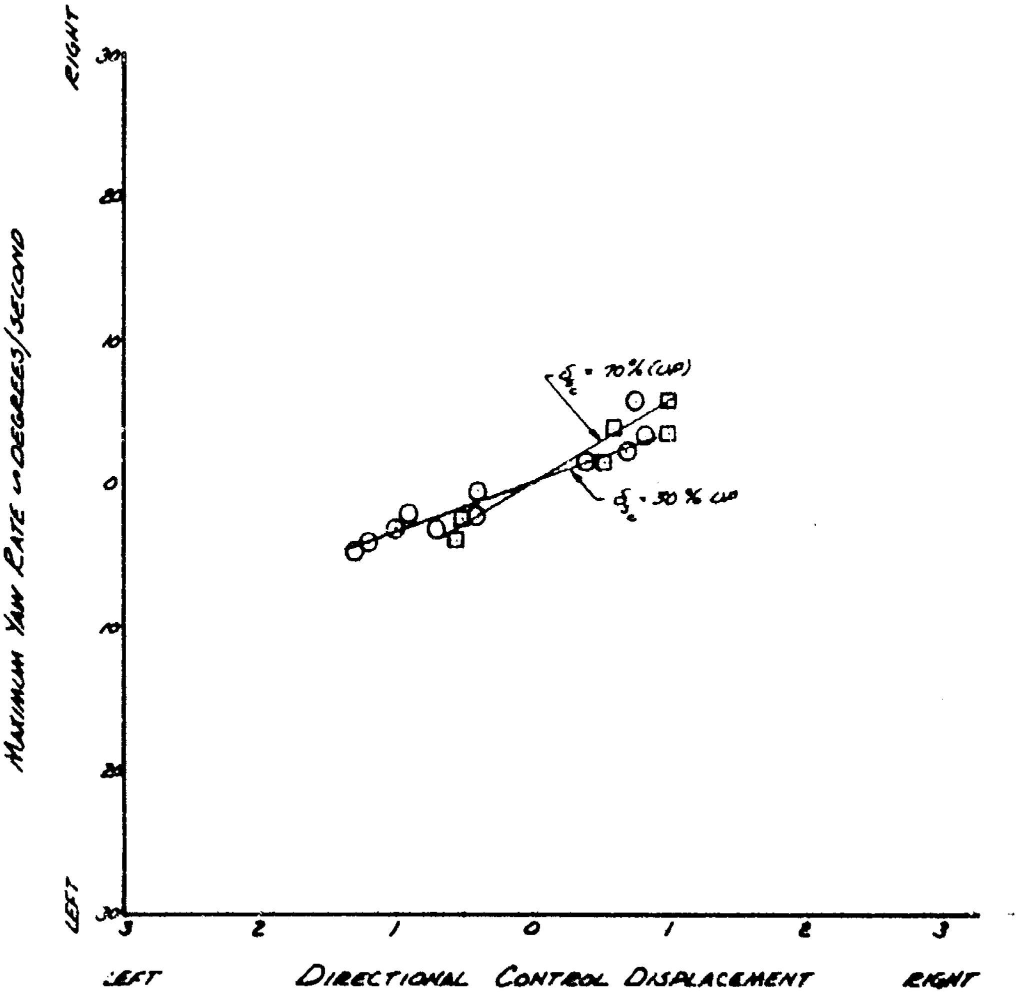


FIGURE No. 85

DIRECTIONAL CONTROL RESPONSE

XV-5A USA S/N 624505

SAS ON PRIMARY

SYM	AIRSPEED V_c ~ KCAS	AVG ALT H_p ~ FT	AVG G.W. ~ LB	AVG C.G. ~ IN	δ_{s_c} ~ % (UP)	CONFIGURATION
△	30	5560	9680	240.7 (MID)	100	FAN MODE (LEVEL FLT)
◇	43	5100	9820	241.0 (MID)	100	FAN MODE (LEVEL FLT)
◁	55	5260	9720	241.2 (MID)	100	FAN MODE (LEVEL FLT)
⬭	70	4230	9710	241.0 (MID)	100	FAN MODE (LEVEL FLT)
△	100	5350	9930	240.8 (MID)	100	PRE - CONV (LEVEL FLT)
⬡	125	4840	9970	240.7 (MID)	100	PRE - CONV (LEVEL FLT)

LANDING GEAR FIXED DOWN WITH HEAT SHIELD INSTALLED.

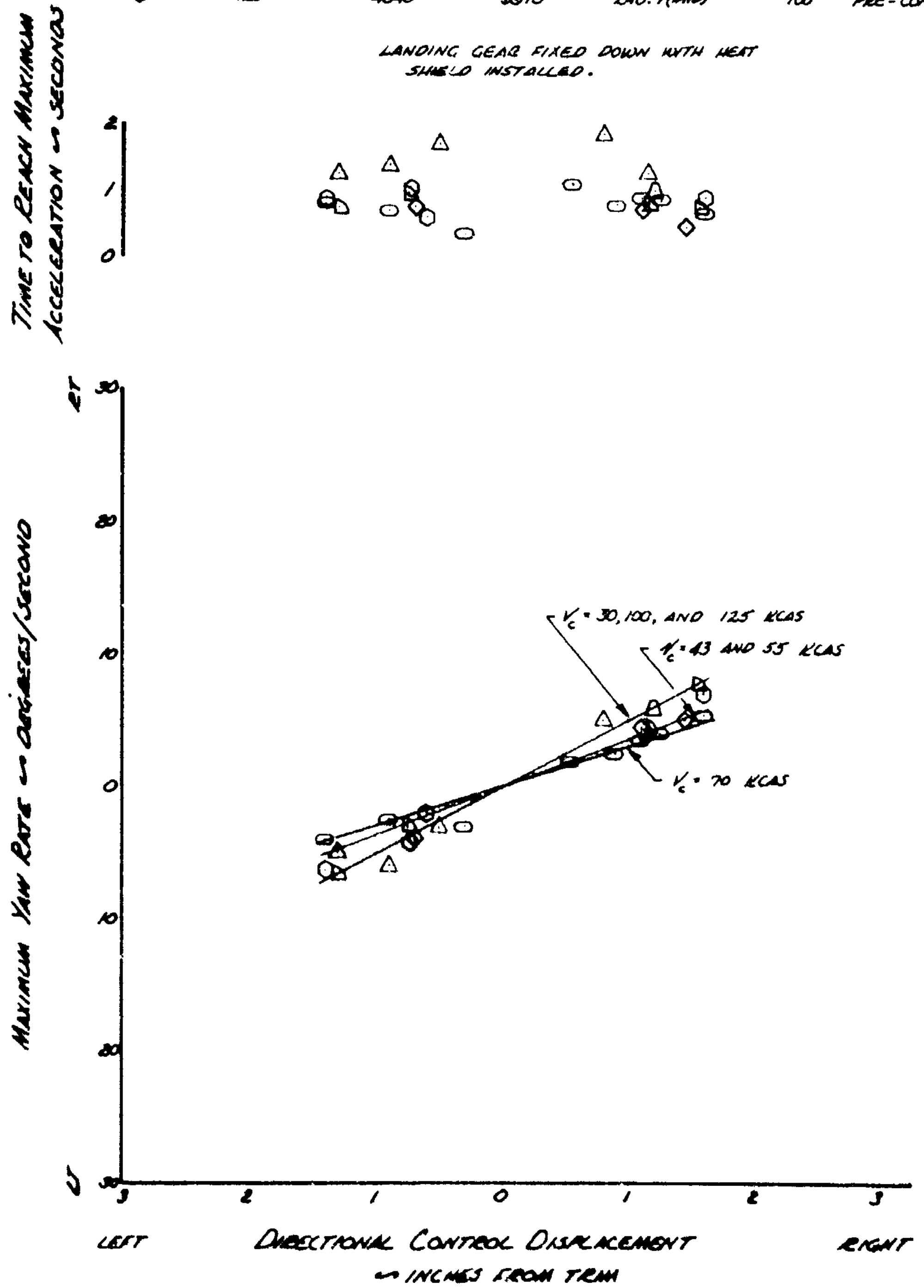
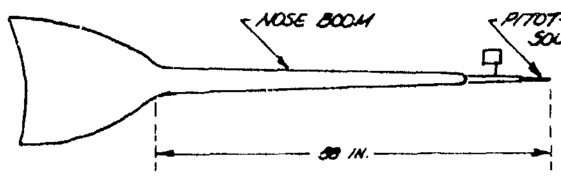


FIGURE NO. 86
AIRSPEED CALIBRATION
XV-5A USA S/N 624505
FAN MODE
NOSE BOOM - LOW SPEED SYSTEM

SYM	GEAR POS.	ANGLE OF ATTACK ~ DEG	AVG ALT H_p ~ FT	AVG G.W. ~ LB	AVG. C.G. LOC ~ IN.
○	DOWN	0	5675	9647	241.1 (MID)
□	DOWN	5	6100	9885	241.0 (MID)
△	DOWN	-2	5710	10170	240.8 (MID)



CALIBRATION FROM PACER TECHNIQUE.
PACE AIRCRAFT, OH-5A HELICOPTER S/N 62-4207
CALIBRATED AIRSPEED EQUALS CORRECTED AIRSPEED PLUS POSITION ERROR.
$V_c = V_{ic} + \Delta V_{P.C.}$

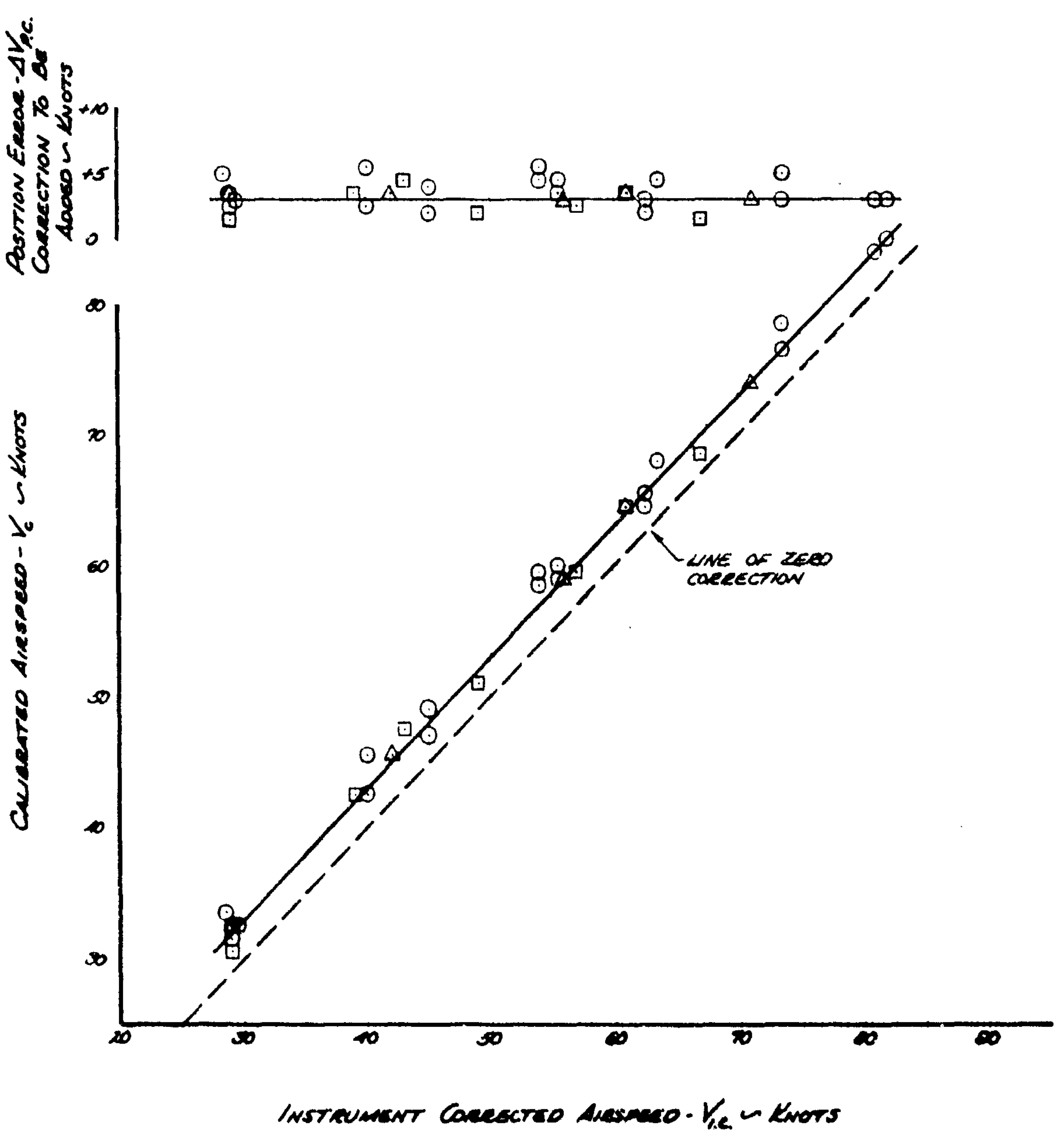


FIGURE No. 87
STATIC TRIM STABILITY
XV-5A USA S/N 62-4505
JET MODE

SYM	GEAR POS	FLAP POS	AVG G.W. ~ LB	AVG C.G LOC ~ IN	AVG. H_P ~ FT
△	UP	0	10140	242.5	5750
○	UP	0	9810	241.9	10000
□	UP	0	9970	242.4	16070
◇	UP	45	10300	242.1	8630

AIRCRAFT TRIMMED FOR CONTROLS FREE LEVEL FLIGHT.

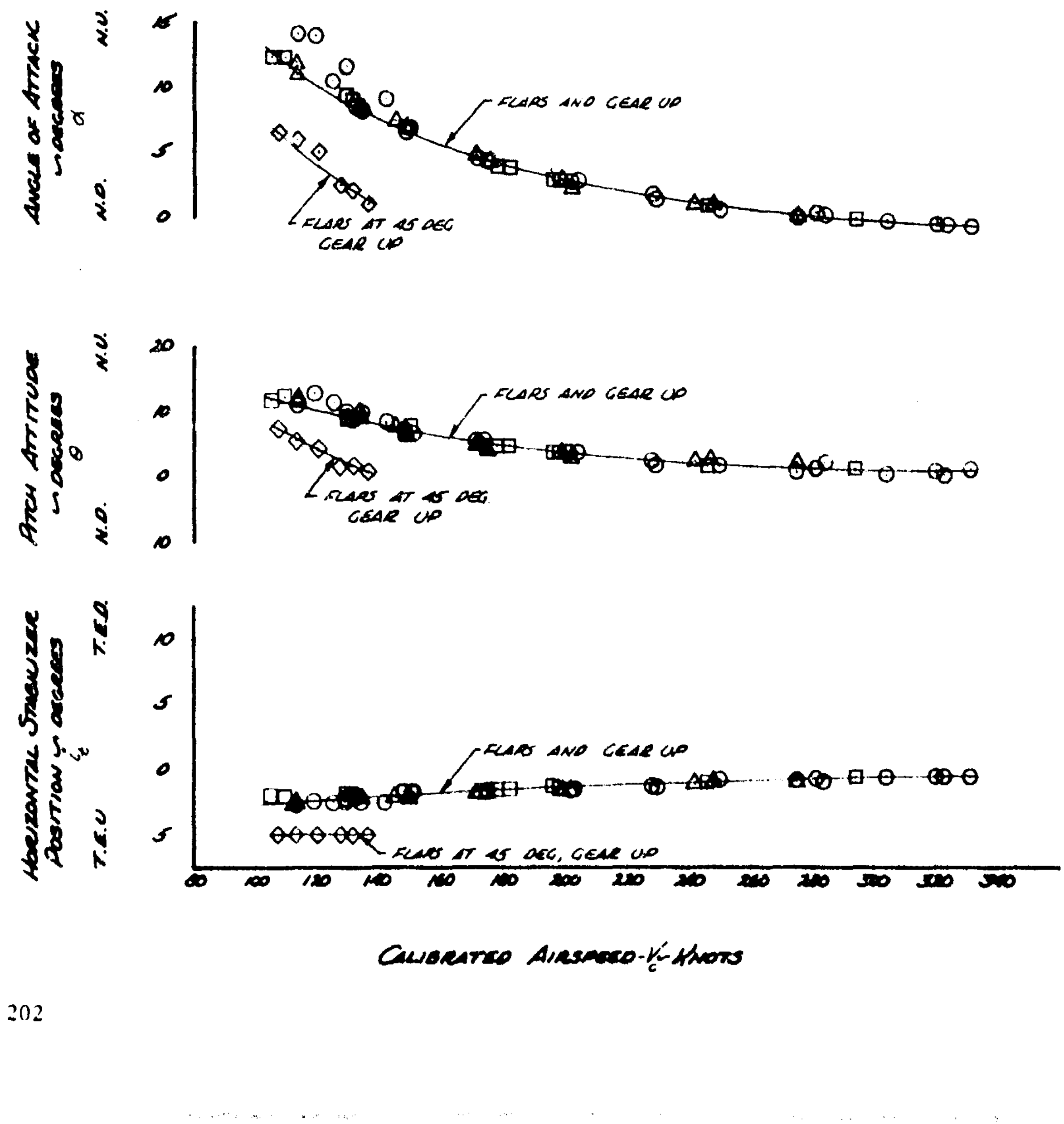


FIGURE No. 88
STATIC TRIM STABILITY
XV-5A USA S/N 62-4505

JET MODE PRE-CONVERSION

SYM	GEAR POS.	FLAP POS ~ %	AVG. G.W. ~ LB.	AVG C.G. LOC. ~ IN.	AVG H_p ~ FT.
○	DOWN	45	10500	240.7	5170
□	UP	45	10210	242.3	5050

AIRCRAFT TRIMMED FOR CONTROLS FREE LEVEL FLIGHT.

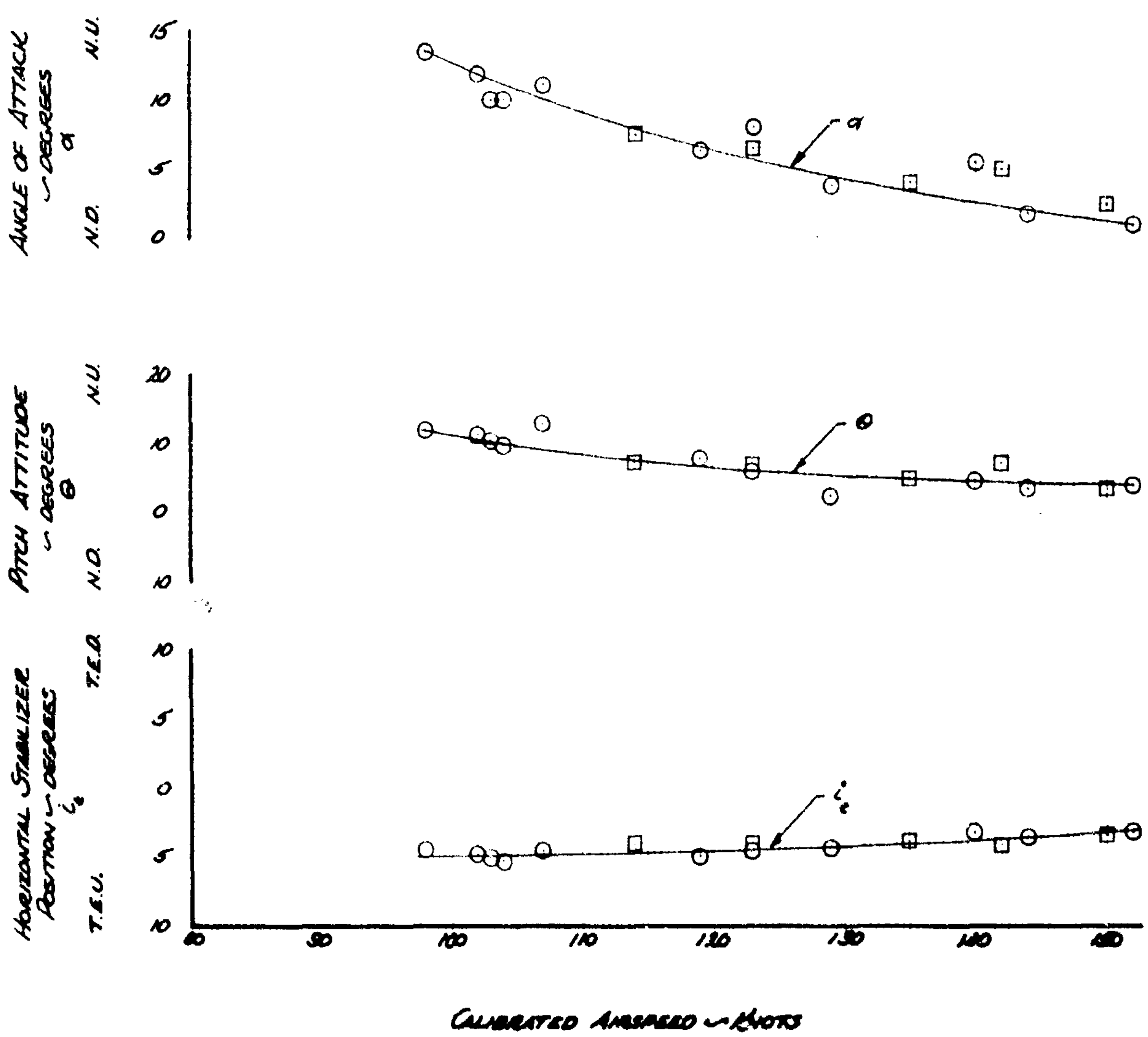
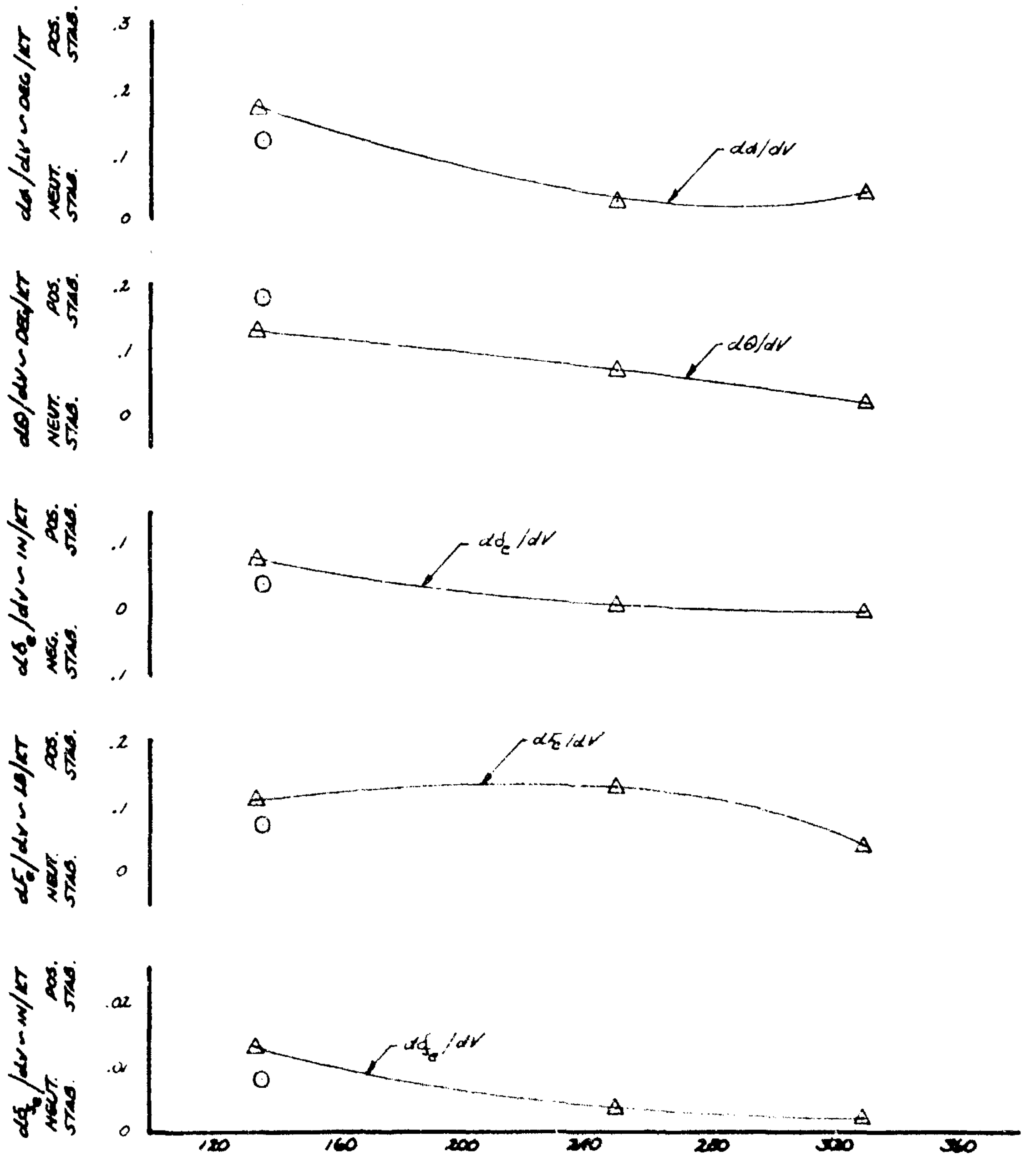


FIGURE No. 89
SUMMARY OF
STATIC LONGITUDINAL STABILITY
XV-5A USA S/N 62-4505
JET MODE

SYM	GEAR POS.	FLAP POS ~ DEG	AVG. G.W. ~ LB	AVG C.G. LOC ~ IN.	AVG ALT - H_p ~ FT
△	UP	0	9900	241.5 (MID)	10000
○	UP	45	10550	242.0 (MID)	9900

DERIVATIVE TAKEN AT THE TRIM POINT FROM FIGURE NO. 90, APPENDIX I.



CALIBRATED AIRSPEED - V_c ~ KNOTS

FIGURE No. 90
STATIC LONGITUDINAL STABILITY
XV-5A USA S/N 62-4505
JET MODE

SYM	GEAR POS	FLAP POS	AVG G.W. ~ LB	AVG CG LOC ~ IN	AVG H_p ~ FT
○	UP	0	10270	241.6	9740
□	UP	0	9510	240.8	10540
△	UP	0	9900	241.8	9550
◇	UP	45°	10350	242.0	9900

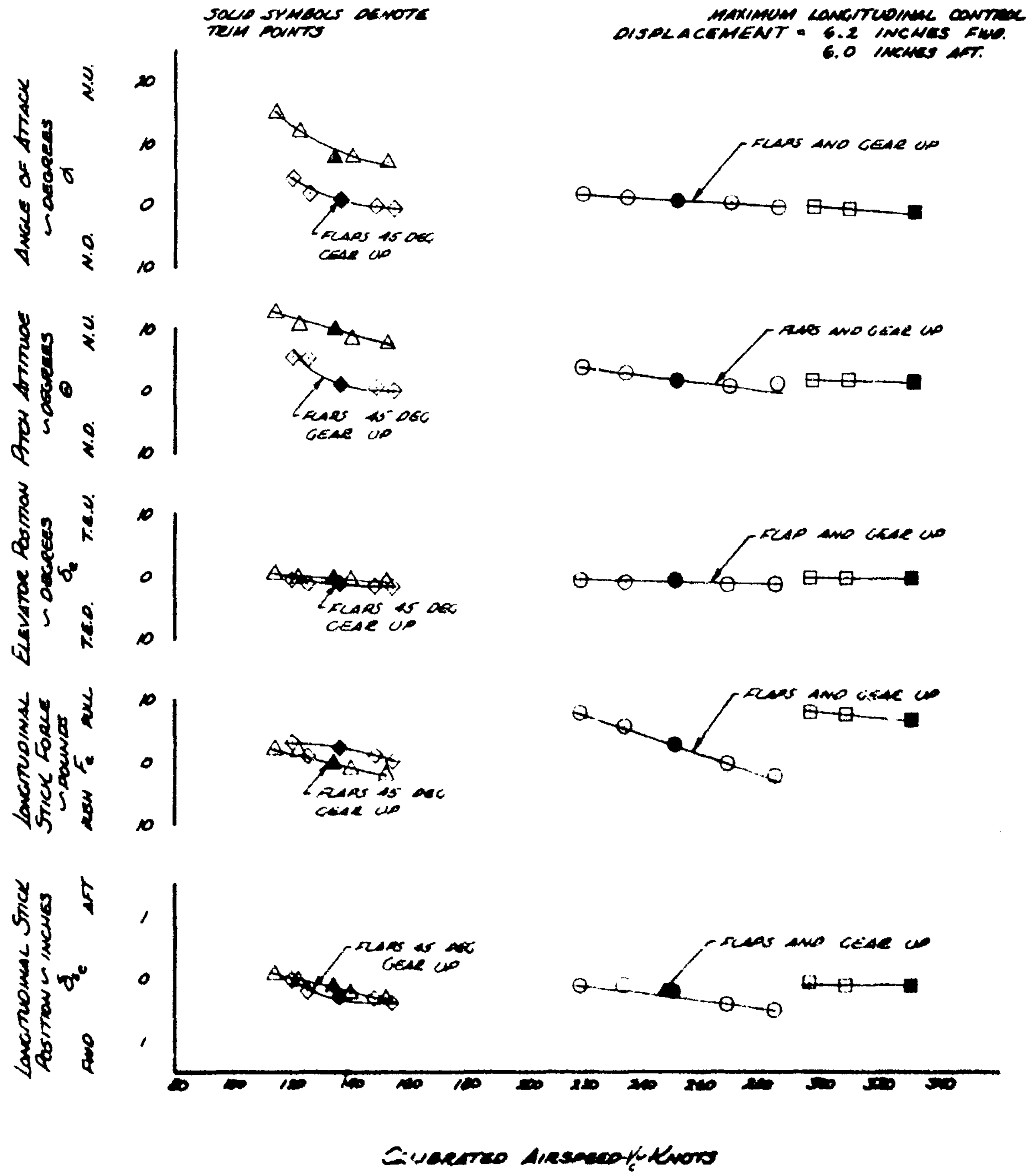


FIGURE No. 91
SUMMARY OF
STATIC LONGITUDINAL STABILITY
XV-5A USA S/N 62-4505
JET MODE PRE-CONVERSION

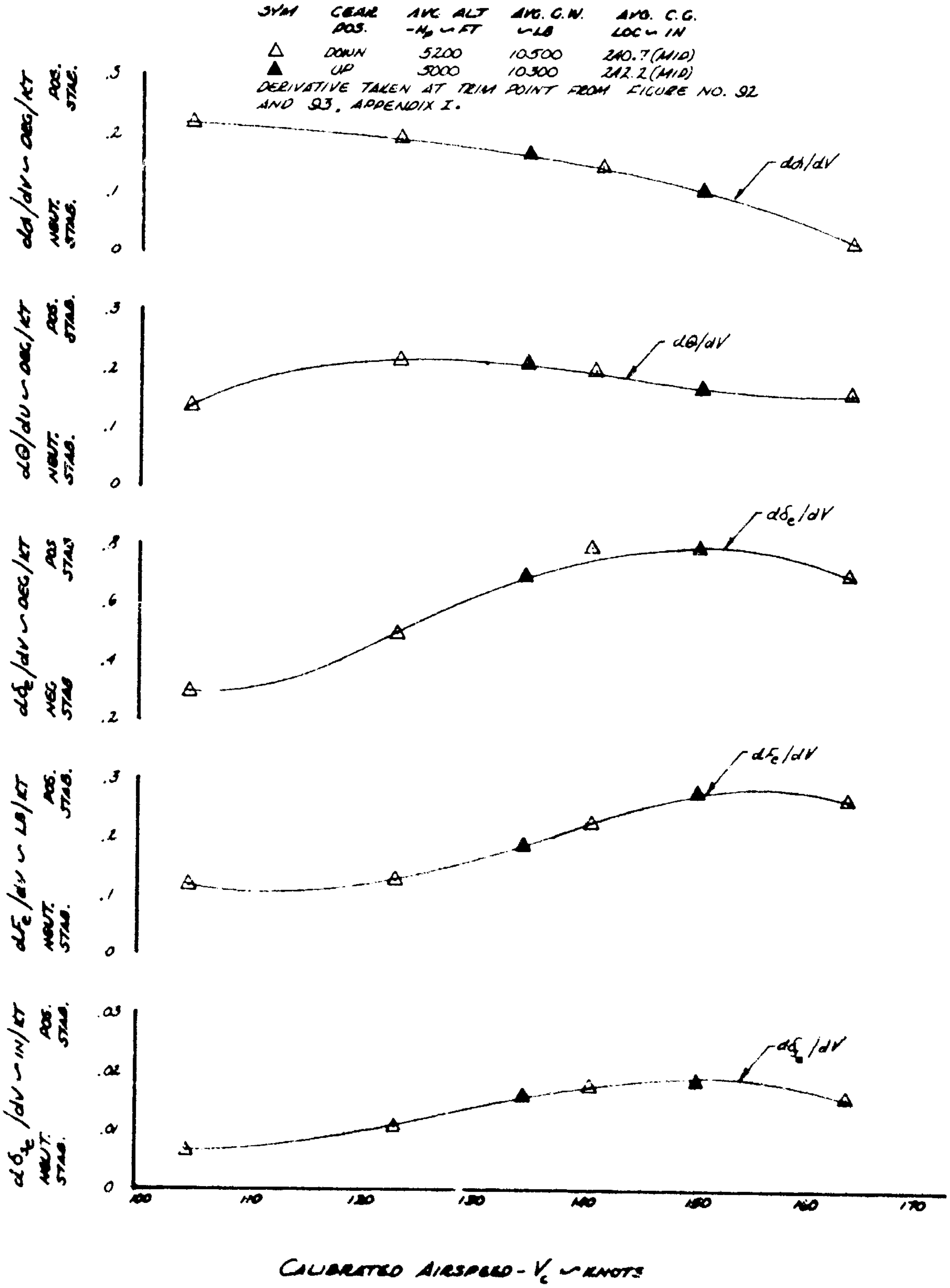


FIGURE No. 92
STATIC LONGITUDINAL STABILITY
XV-5A USA S/N 62-4505
JET MODE PRE-CONVERSION

SYM	GEAR POS.	FLAP POS.	AVG. G.W ~ LB	AVG. C.G. LOC. ~ IN.	AVG H_p ~ FT	HOR STAB POS ~ DEG
○	UP	45°	10615	241.8	5000	3.3 T.E.U.
□	UP	45°	10110	242.5	5140	4.0 T.E.U.

SOLID SYMBOLS DENOTE LEVEL FLIGHT TRIM POINTS.

MAXIMUM LONGITUDINAL CONTROL DISPLACEMENT = 6.2 IN. FWD, 6.0 IN AFT.

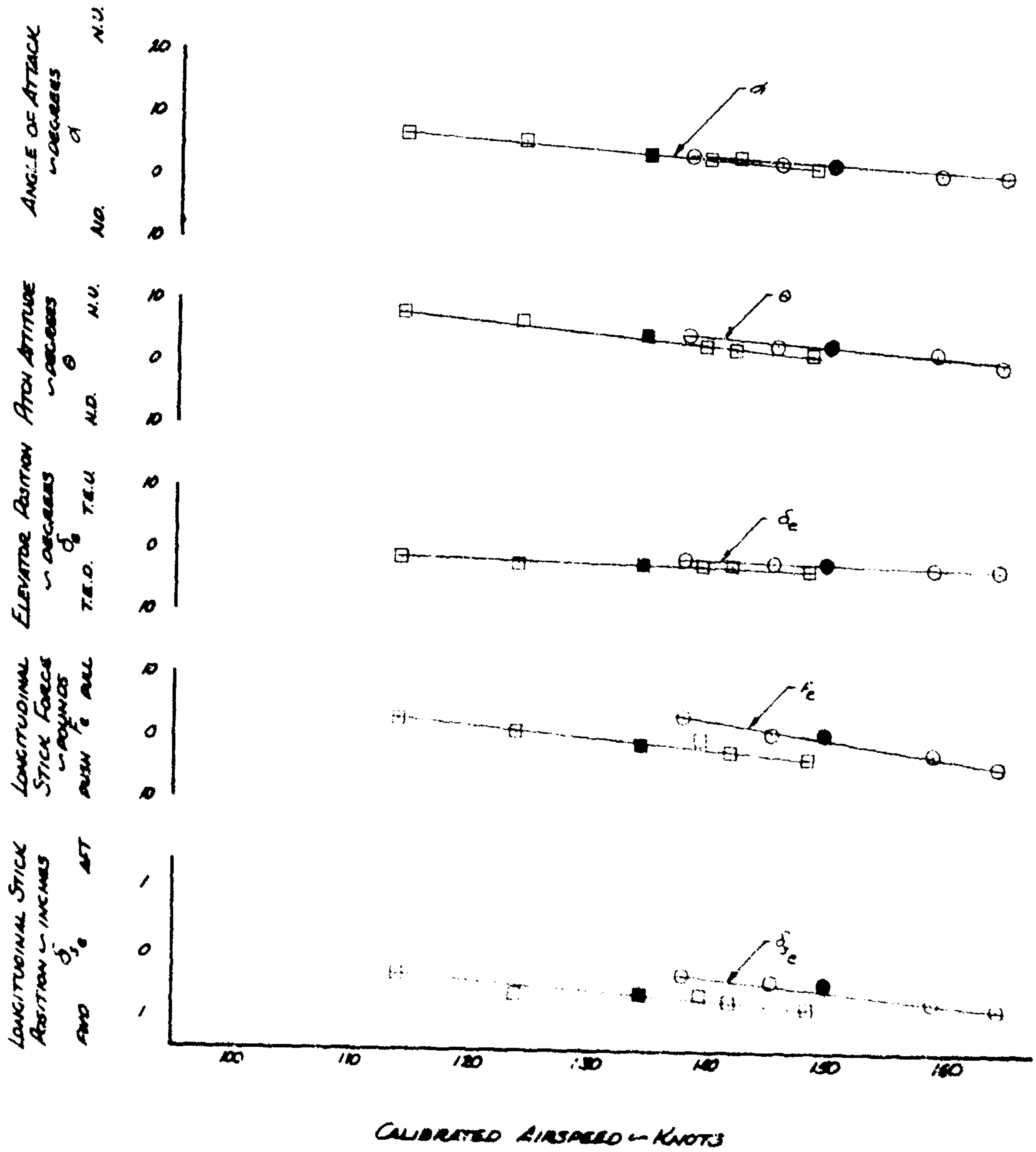


FIGURE No. 93
STATIC LONGITUDINAL STABILITY
XV-5A USA S/N 62-4505

JET MODE PRE CONVERSION

SYM	GEAR POS	FLAP POS	AVG. G.W ~ LB	AVG C.G. ~ IN.	AVG H_p ~ FT	HOR STAB. POS ~ DEG
○	DOWN	45°	10830	240.9	5470	3.3 T.E.U.
□	DOWN	45°	10540	240.9	4650	4.1 T.E.U.
◇	DOWN	45°	10440	240.7	5120	4.0 T.E.U.
△	DOWN	45°	10370	240.5	5800	2.8 T.E.U.

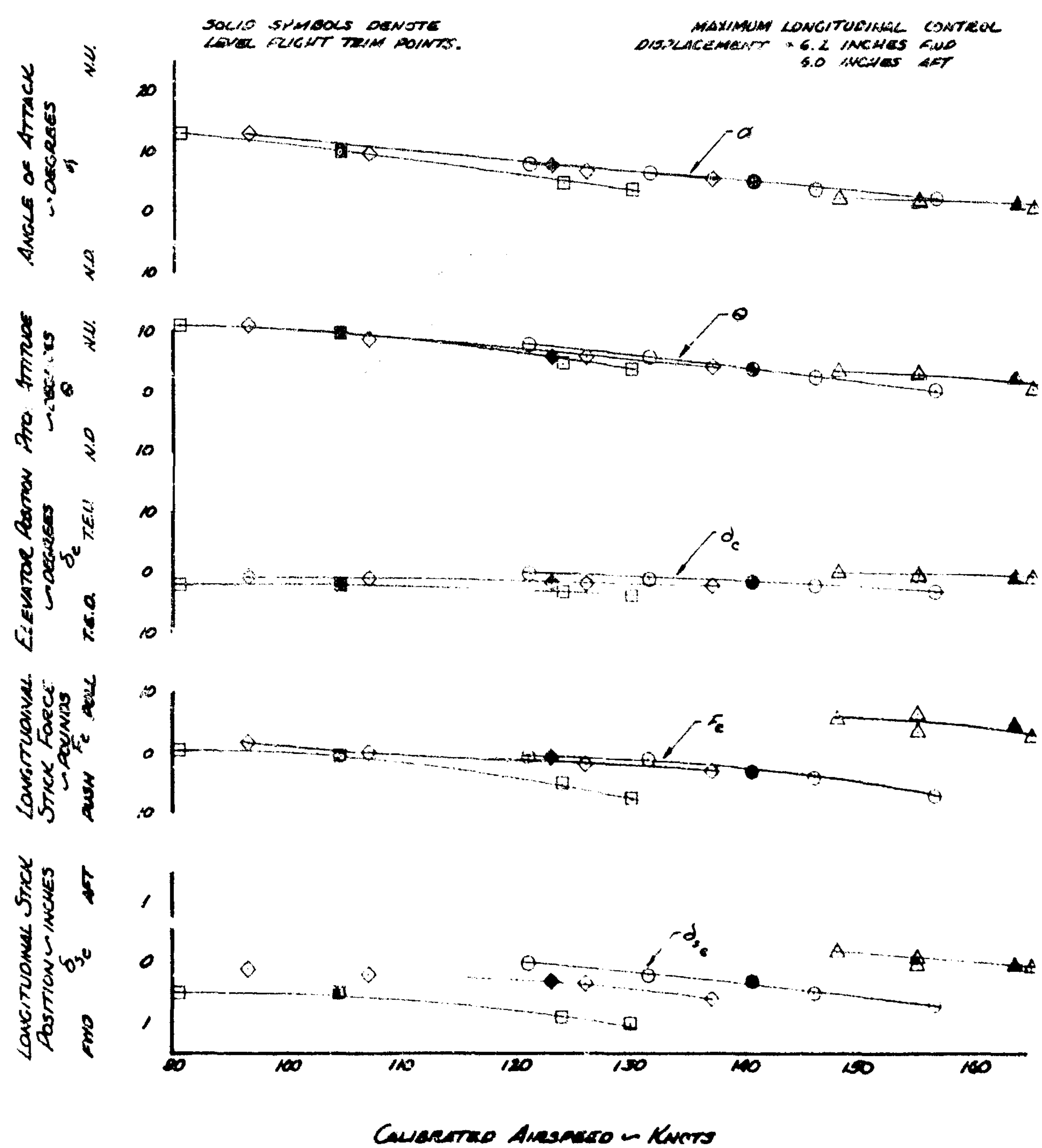


Figure No. 94

HORIZONTAL STABILIZER TRIM EFFECTIVENESS

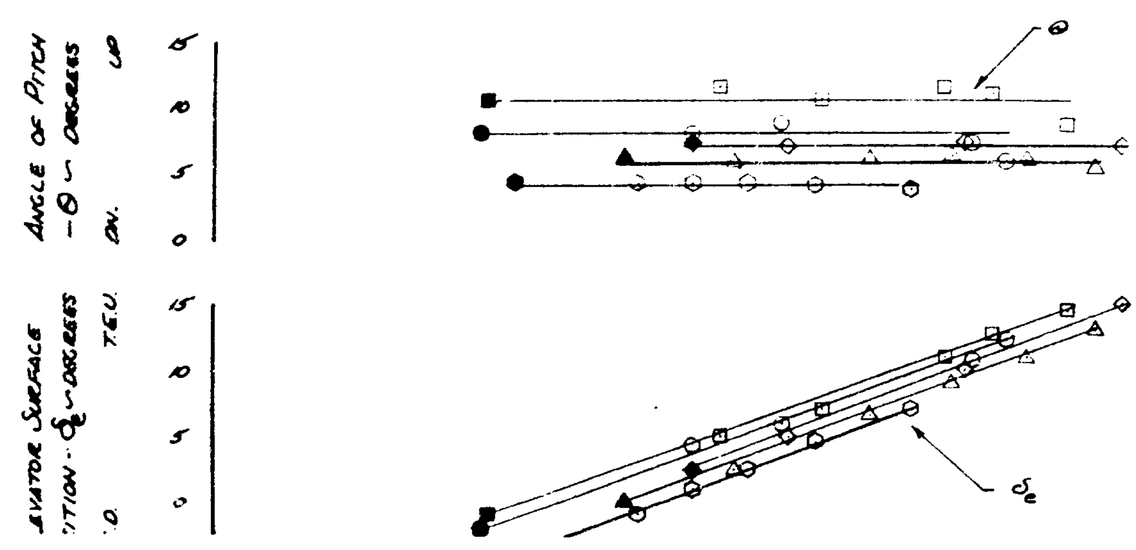
XV-5A USA S/N 62-4505

JET MODE PRE-CONVERSION

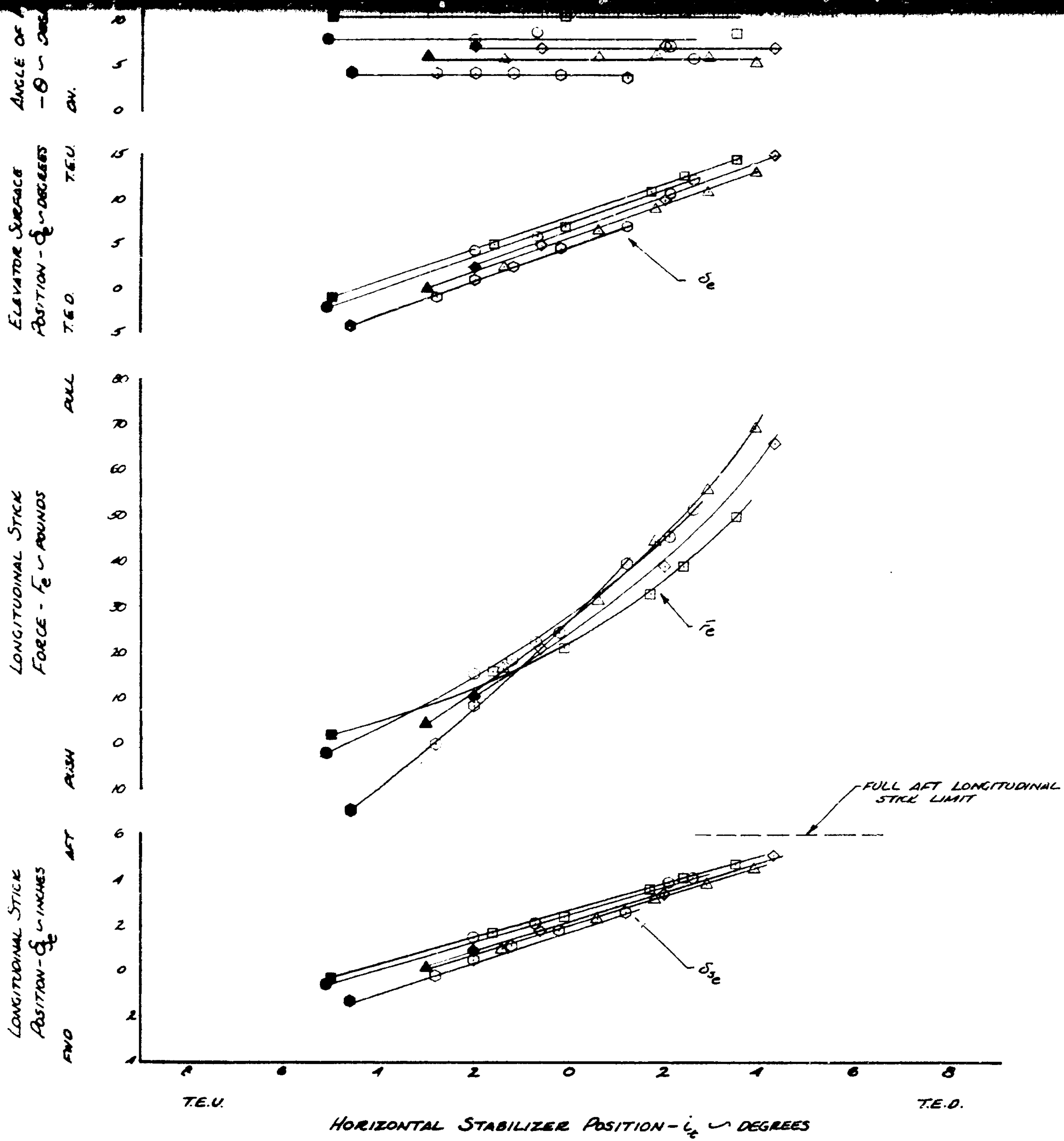
SYM	TRIM A/S $-V_c$ ~ KTS.	AVG ALT H_p ~ FT	AVG G.W. ~ LB	AVG C.G. LOC ~ IN	TRIM ANGLE OF ATTACK ~ DEG
□	105	4890	10664	240.3	10.0
○	118	5250	10665	240.3	7.5
◇	134	5300	10520	240.5	5.0
△	142	5780	10600	240.3	4.0
⬡	155	5660	10530	240.4	2.5

MAXIMUM LONGITUDINAL CONTROL DISPLACEMENT = 6.2 IN. FWD.
6.0 IN. AFT.

MAXIMUM HORIZONTAL STABILIZER DEFLECTION = 5 DEG T.E.U. TO 19.6 T.E.D.
SOLID SYMBOLS DENOTE TRIM POINTS
TRIM ANGLE OF ATTACK MAINTAINED CONSTANT



A



ANGLE OF
$-\theta$ ~ DEG
ON.
ELEVATOR SURFACE
POSITION - δ_e ~ DEGREES
T.E.U.
T.E.D.
δ_e
LONGITUDINAL STICK
FORCE - F_e ~ POUNDS
PULL
PUSH
F_e
FULL AFT LONGITUDINAL STICK LIMIT
LONGITUDINAL STICK
POSITION - δ_{s_e} ~ INCHES
AFT
FWD
δ_{s_e}
T.E.U.
T.E.D.
HORIZONTAL STABILIZER POSITION - i_t ~ DEGREES

B

FIGURE No. 95
SUMMARY OF
STATIC LATERAL DIRECTIONAL STABILITY
XV-5A USA S/N 62-4505
JET MODE

SYM	GEAR POS.	FLAP POS. ~ DEG.	AVG ALT. -H_p ~ FT.	AVG G.W. ~ LB	AVG C.G. LOC ~ IN.
OPEN	UP	0	9160	9650	242.2 (MID)
SOLID	UP	45	9840	10730	240.7 (MID)

DERIVATIVE TAKEN AT THE TRIM POINT FROM FIGURE NO. 96 THROUGH 99, APPENDIX I.

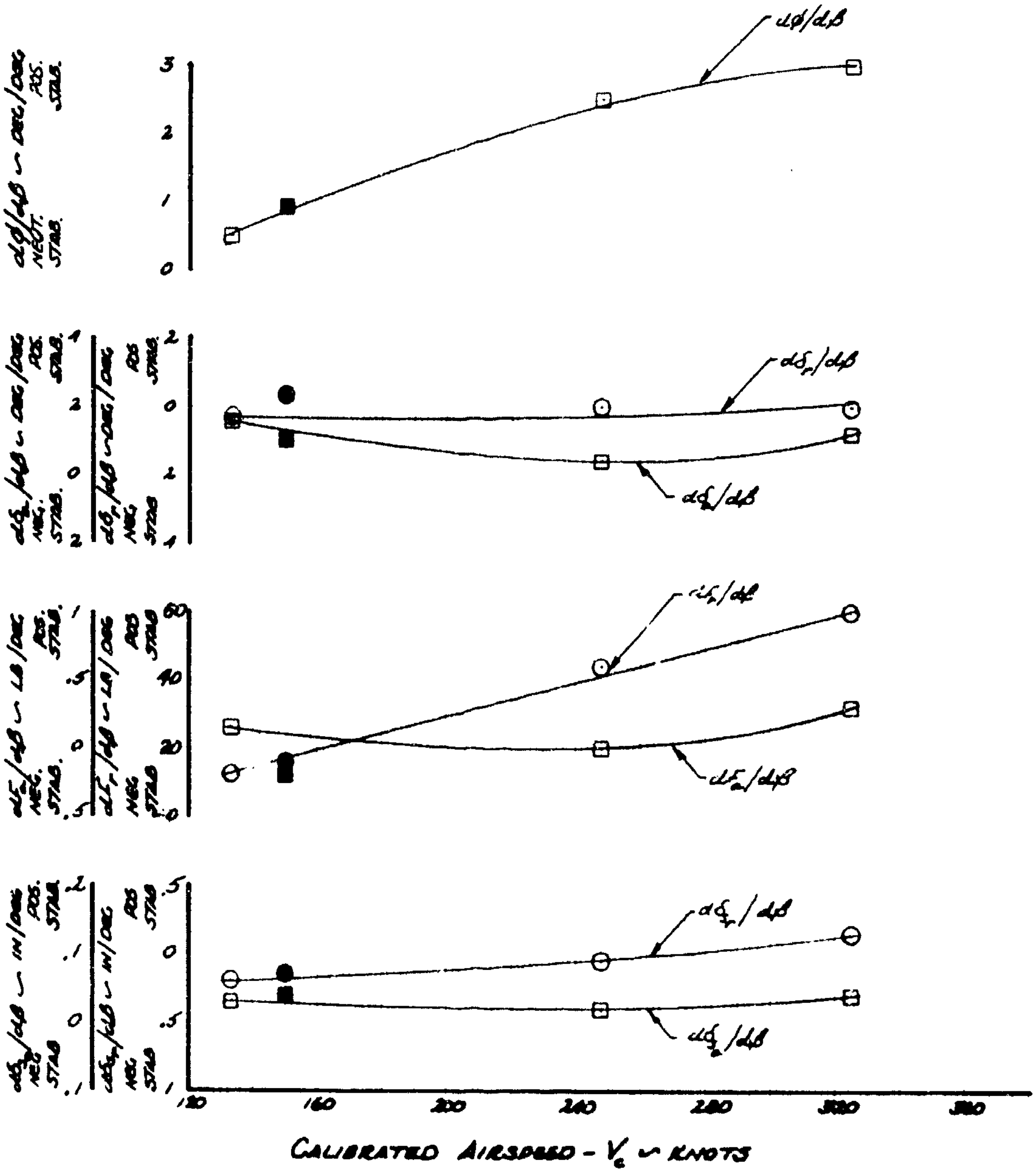


FIGURE No. 96

STATIC LATERAL-DIRECTIONAL STABILITY

XV-5A USA S/N 62-4505

JET MODE

TRIM A/S = 133 KCAS
AVG H_p = 9660 FT
LANDING GEAR: UP
AVG. G.W = 9540 LB
AVG. C.G = 243.3 IN(MID)
FLAP POSITION = 6 DEG.
HOR. STAB POS = 2.2 DEG. T.E.U.

SOLID SYMBOLS DENOTE TRIM POINTS.

MAXIMUM CONTROL DISPLACEMENT
LONGITUDINAL = 6.2 IN. FWD., 6.0 IN AFT
LATERAL = 3.9 IN. RT, 3.2 IN LT.
PEDAL = 3.5 IN. RT 3.5 IN LT.

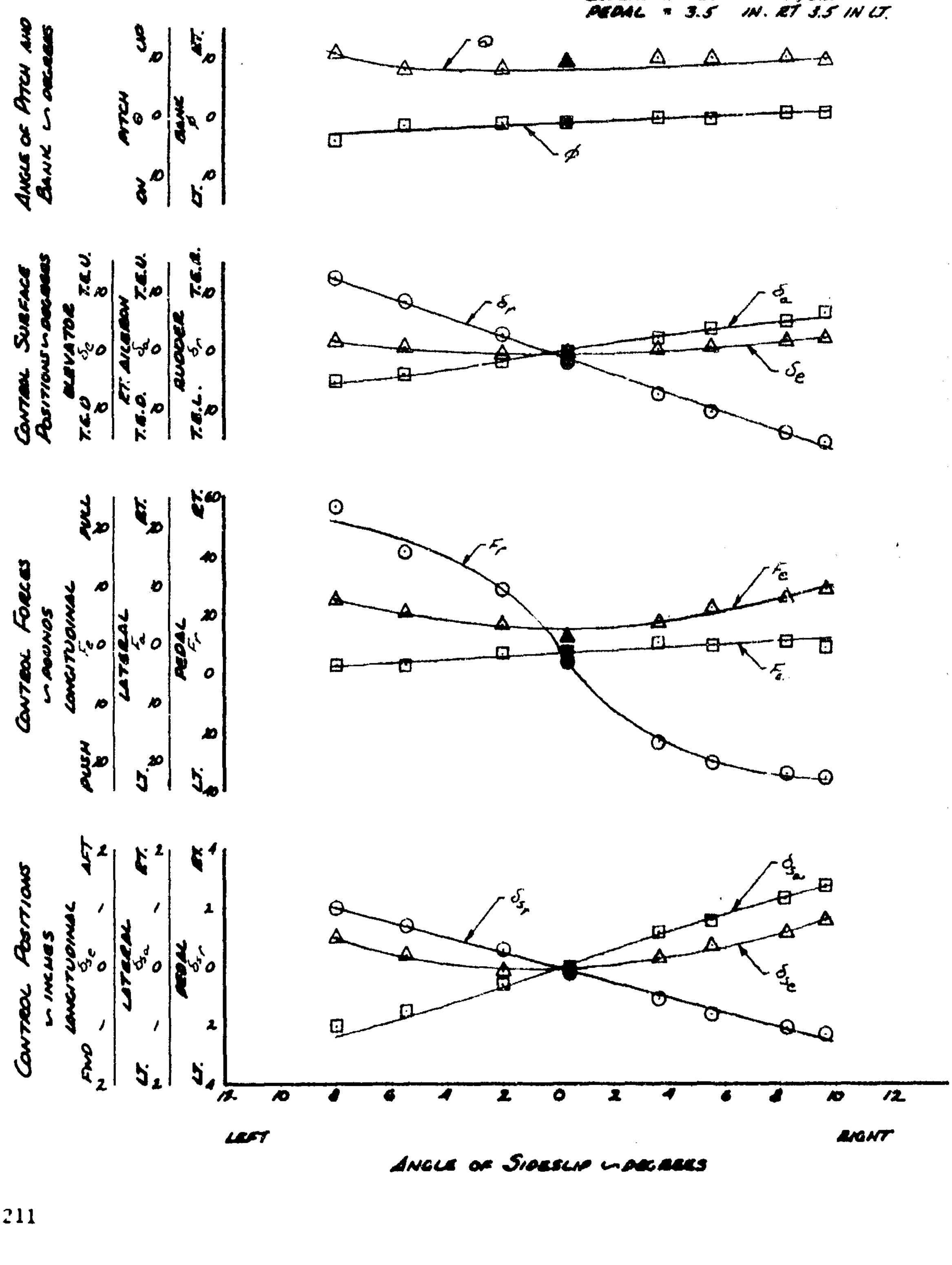


FIGURE No. 97

STATIC LATERAL-DIRECTIONAL STABILITY

XV-5A USA S/N 62-4505

JET MODE

TRIM A/S = 150 KCAS
AVG H_p = 9840 FT
LANDING GEAR: UP
AVG. G.W. = 10730 LB
AVG. C.G = 240.7 IN(MID)
FLAP POSITION = 45 DEG.
HOR. STAB. POS = 1.0 DEG T.E.U.

SOLID SYMBOLS DENOTE TRIM POINTS.

MAXIMUM CONTROL DISPLACEMENT
LONGITUDINAL = 6.2 IN. FWD, 6.0 IN AFT
LATERAL = 3.9 IN. RT, 3.2 IN. LT.
PEDAL = 3.5 IN. RT, 3.5 IN LT.

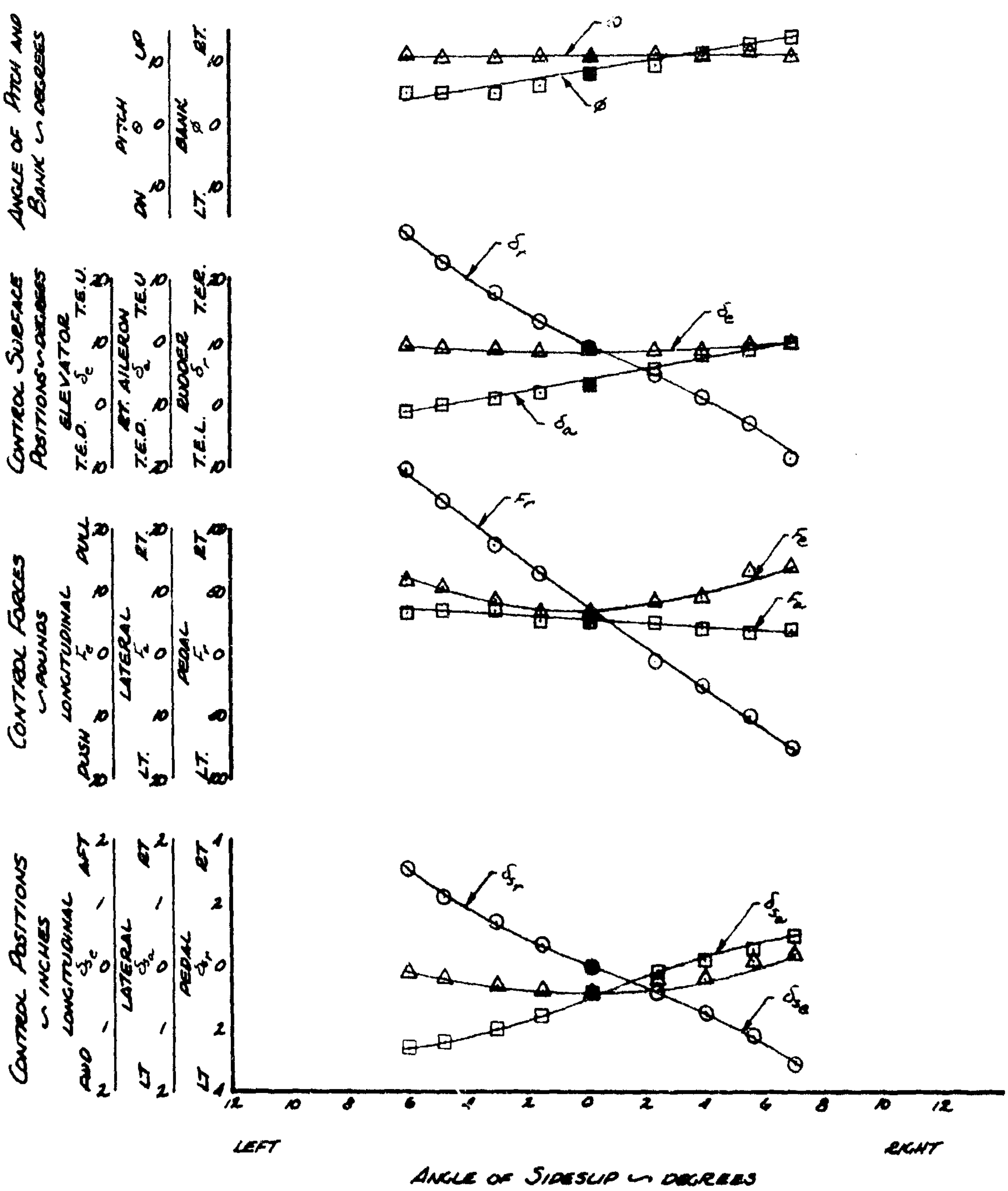


FIGURE No. 98

STATIC LATERAL-DIRECTIONAL STABILITY

XV-5A USA S/N 62-4505

JET MODE

TRIM A/S = 248 KCAS
AVG H_p = 9780 FT
LANDING GEAR : UP
AVG G.W. = 9960 LB.
AVG C.G. = 241.4 IN. (MID)
FLAP POSITION : 0 DEG.
HOR. STAB. POS = 1.0 DEG. T.E.U.

SOLID SYMBOLS DENOTE TRIM POINTS.

MAXIMUM CONTROL DISPLACEMENT
LONGITUDINAL = 6.2 IN. FWD, 6.0 IN AFT
LATERAL = 3.9 IN. RT, 3.2 IN LT.
PEDAL = 3.5 IN. RT, 3.5 IN. LT.

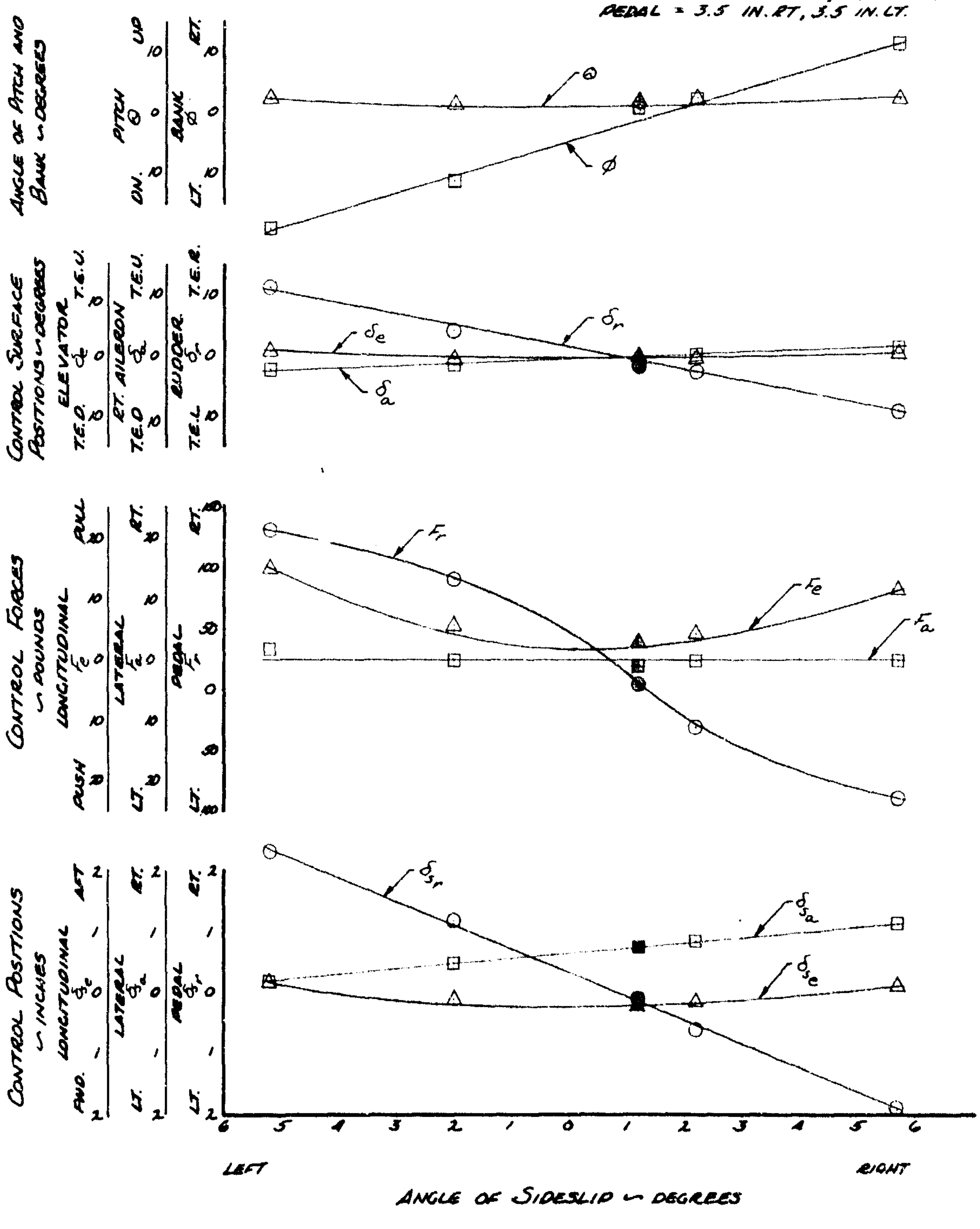


FIGURE NO. 99

STATIC LATERAL-DIRECTIONAL STABILITY

XV-5A USA S/N 62-4505

JET MODE

TRIM A/S = 325 KCAS
AVG H_p = 9050 FT
LANDING GEAR: UP
AVG G.W. = 9580 LB
AVG C.G. = 241.9 IN(MID)
FLAP POSITION = 0 DEG.
HOR. STAB. POS = 0.6 DEG. T.E.U.

SOLID SYMBOLS DENOTE TRIM POINTS.

MAXIMUM CONTROL DISPLACEMENT
LONGITUDINAL = 6.2 IN. FWD, 6.0 IN AFT
LATERAL = 3.9 IN. RT, 3.2 IN. LT.
PEDAL = 3.5 IN. RT, 3.5 IN. LT.

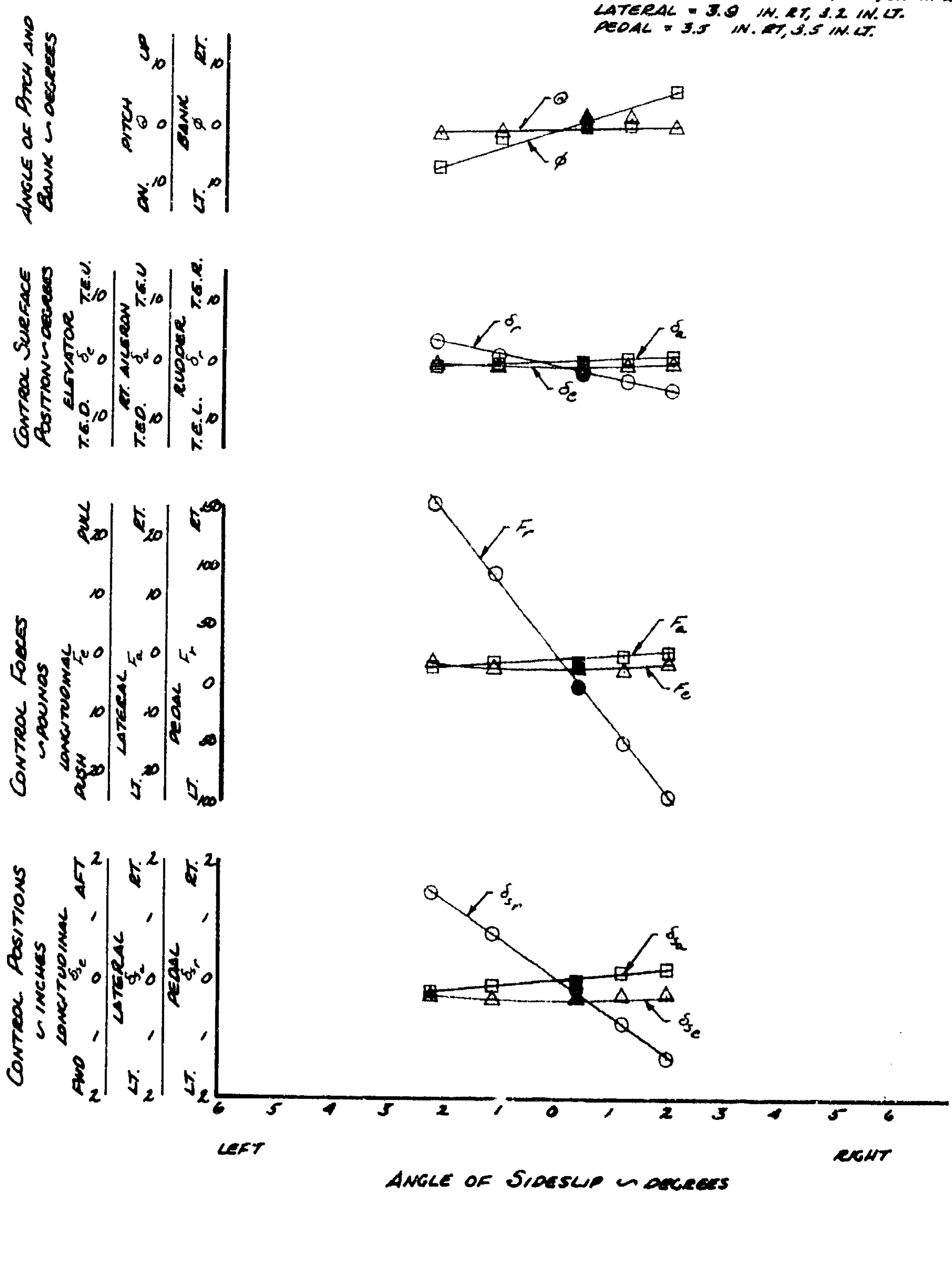
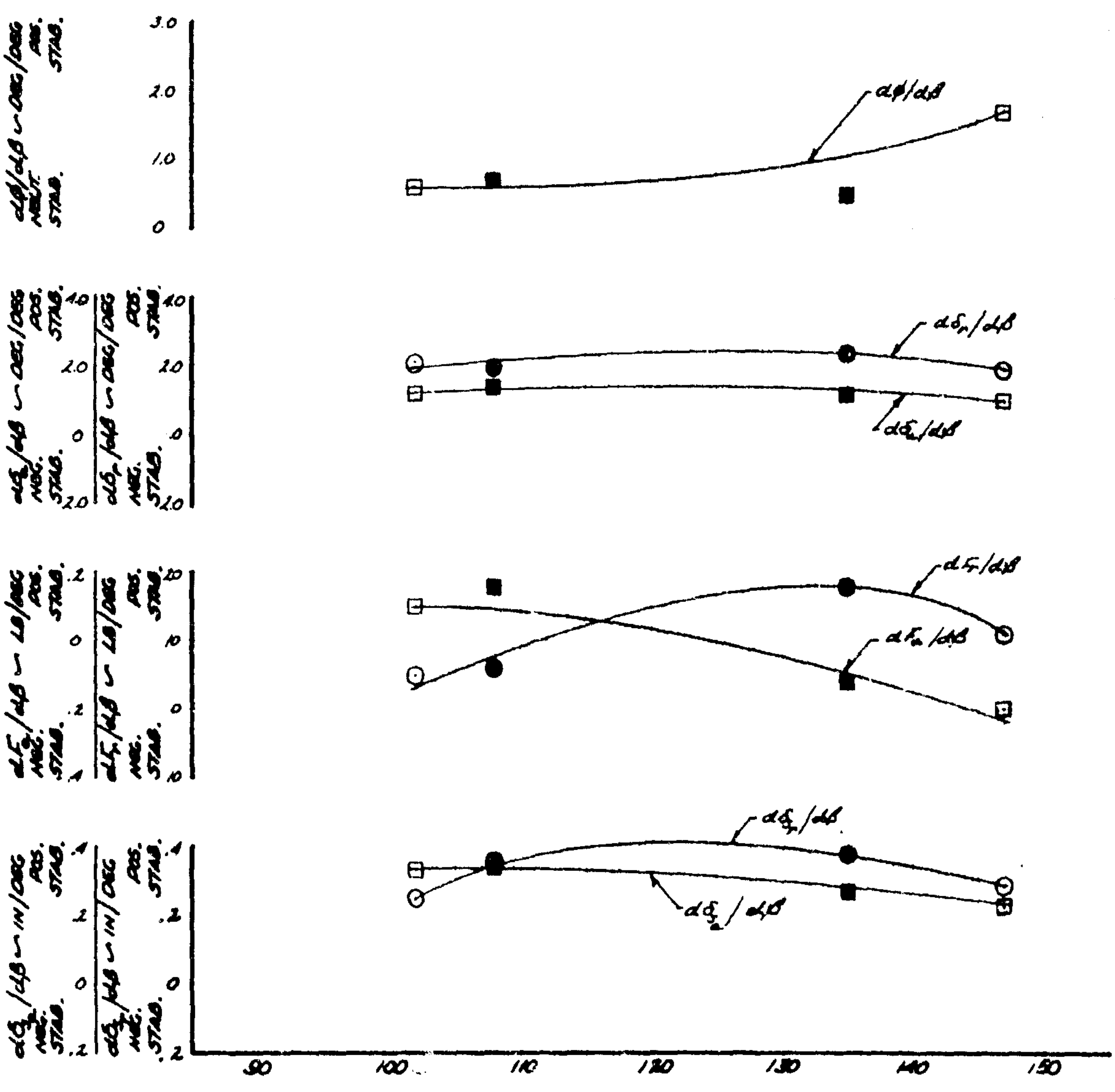


FIGURE No. 100
SUMMARY OF
STATIC LATERAL DIRECTIONAL STABILITY
XV-5A USA S/N 624505
JET MODE PRE-CONVERSION

SYM	GEAR POS	AVG ALT -H_p ~ FT	AVG. G.W ~LB	AVG. C.G LOC ~ IN.
□	UP	4970	10080	241.8(MID)
■	DOWN	5490	10720	241.0(MID)

DERIVATIVE TAKEN AT THE TRIM POINT FIGURE NO. 101 THROUGH 104, APPENDIX I.



CALIBRATED AIRSPEED - V_c ~ KNOTS

FIGURE No. 101
STATIC LATERAL-DIRECTIONAL STABILITY
XV-5A USA S/N 62-4505
JET MODE PRE-CONVERSION

TRIM A/S = 102 KCAS
AVG Hp = 4940 FT
LANDING GEAR: UP

AVG. G.W. = 9490 LB.
AVG. C.G. = 241.9 IN(MID)
HOR. STAB. POS = 5.0 DEG. T.E.U.

SOLID SYMBOLS DENOTE TRIM POINTS.

MAXIMUM CONTROL DISPLACEMENT
LONGITUDINAL = 6.2 IN FWD, 6.0 IN. AFT
LATERAL = 3.9 IN. RT, 3.2 IN. LT.
PEDAL = 3.5 IN RT, 3.5 IN LT.

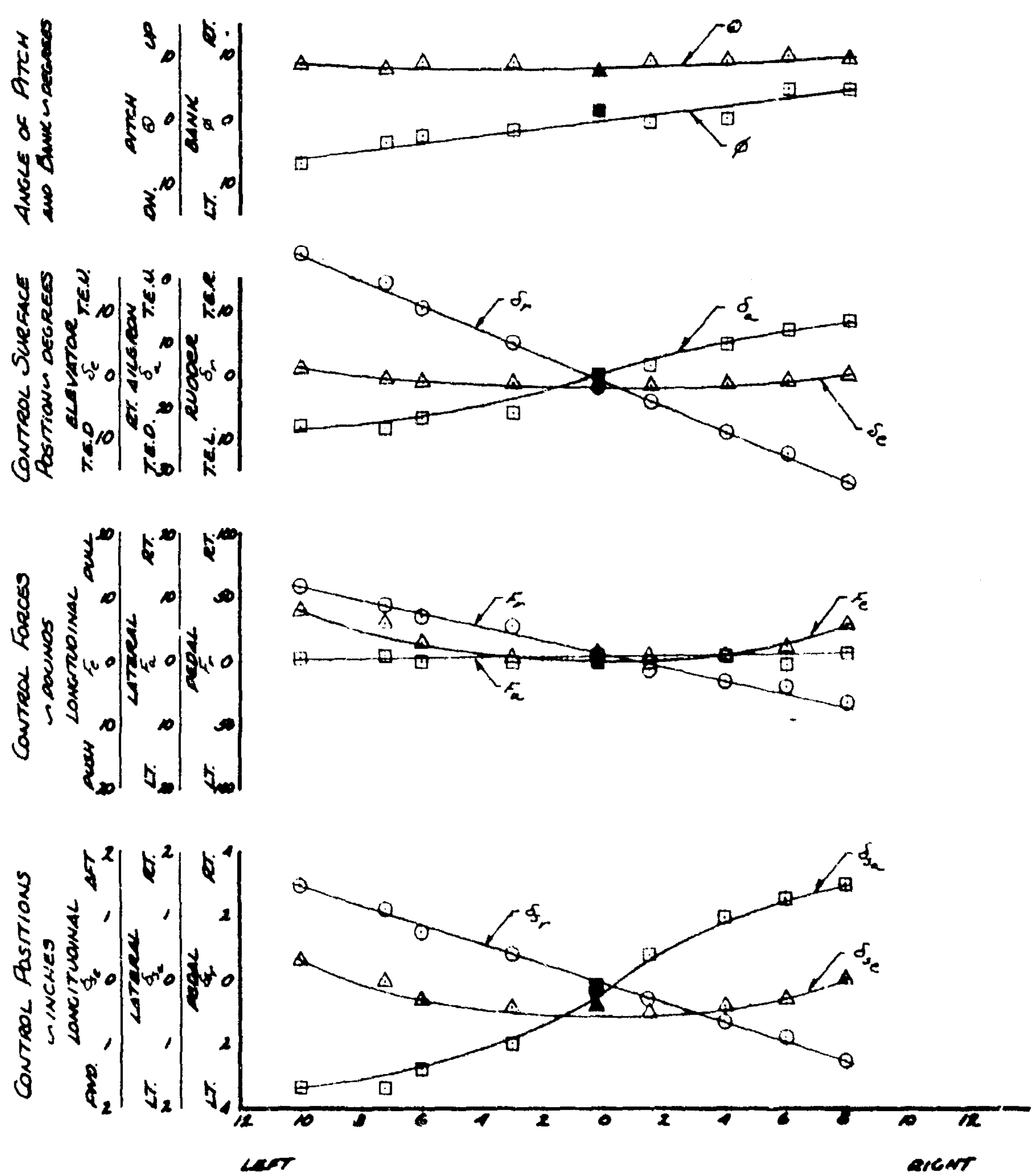


FIGURE No. 102
STATIC LATERAL-DIRECTIONAL STABILITY
XV-5A USA S/N 62-4505
JET MODE PRE-CONVERSION

TRIM A/S = 147 KCAS
AVG. H_p = 5000 FT
LANDING GEAR UP

AVG. G.W. = 10675 LB.
AVG. CG. = 241.8 IN.(MID)
HOR. STAB. POS. = 3.3 DEG. T.E.U.

SOLID SYMBOLS DENOTE TRIM POINTS.

MAXIMUM CONTROL DISPLACEMENT
LONGITUDINAL = 6.2 IN. FWD, 6.0 IN AFT
LATERAL = 3.9 IN RT, 3.2 IN LT.
PEDAL = 3.5 IN. RT, 3.5 IN. LT.

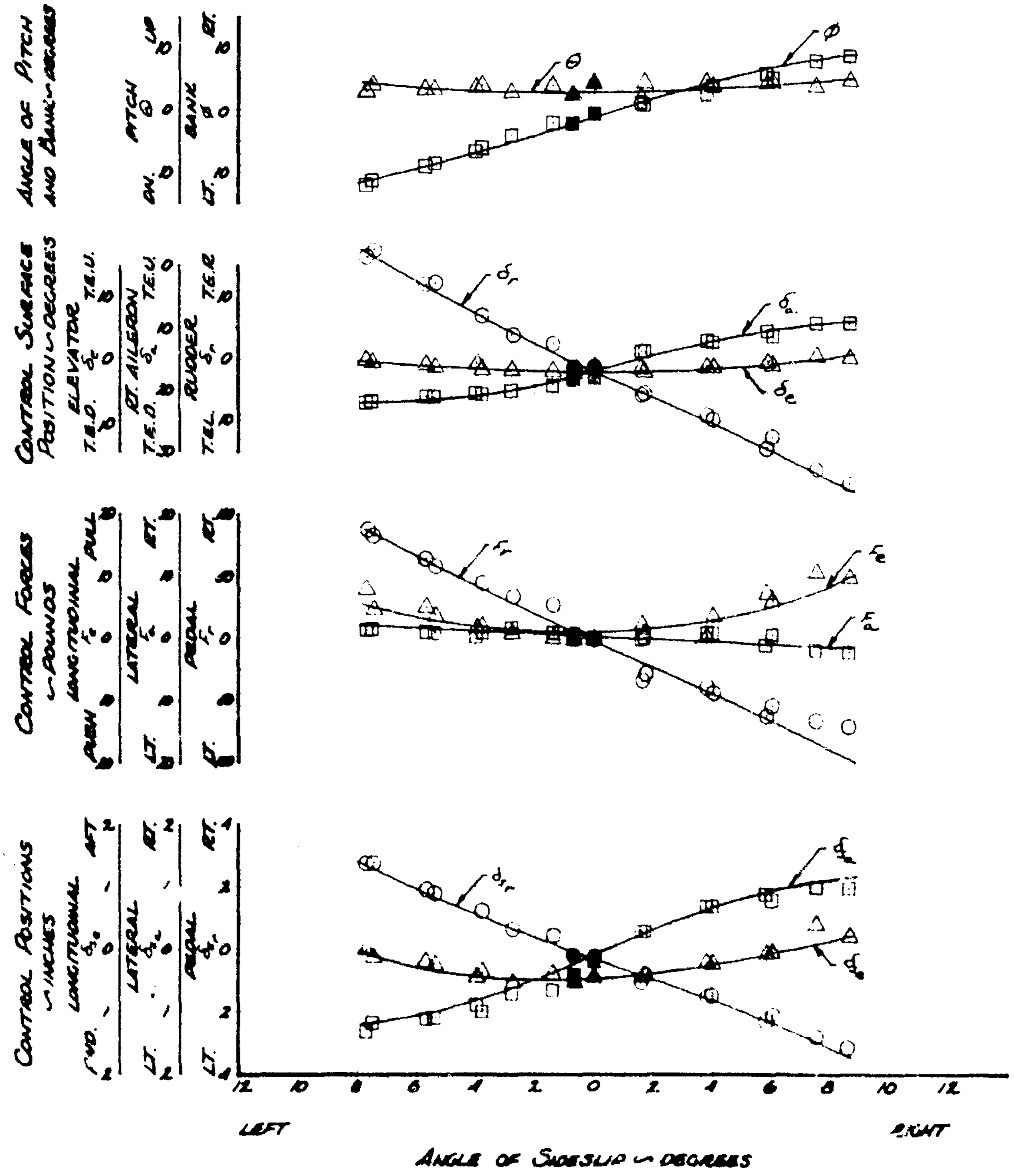


FIGURE NO. 103

STATIC LATERAL-DIRECTIONAL STABILITY

XV-5A USA S/N 62-4505

JET MODE PRE-CONVERSION

TRIM A/S = 108 KCAS
AVG H_p = 5650 FT
LANDING GEAR: DOWN

AVG. G.W. = 10800 LB
AVG C.G = 241.4 IN. (MID)
HOR. STAB. POS = 4.9 DEG. T.E.U.

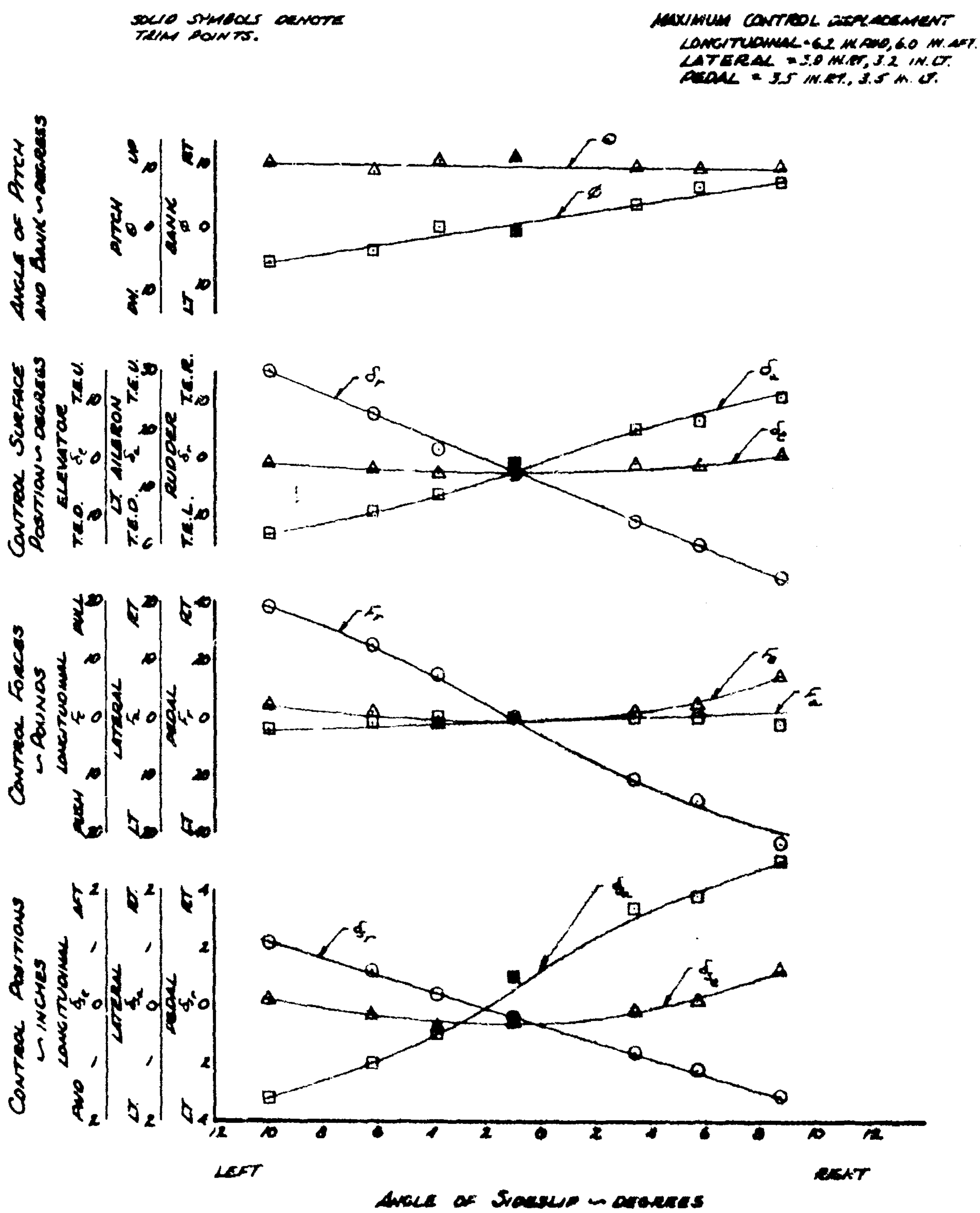


FIGURE No. 104

STATIC LATERAL-DIRECTIONAL STABILITY

XV-5A USA S/N 62-4505

JET MODE PRE-CONVERSION

TRIM A/S = 135 KCAS
AVG H_p = 5330 FT.
LANDING GEAR: DOWN

AVG. G.W. = 10630 LB.
AVG C.G. = 240.6 IN.(MID)
HOR. STAB POS = 4.0 DEG. T.E.U.

SOLID SYMBOLS DENOTE TRIM POINTS

MAXIMUM CONTROL DISPLACEMENT
LONGITUDINAL = 6.2 IN. FWD, 6.0 IN. AFT
LATERAL = 3.9 IN. RT., 3.2 IN. LT.
PEDAL = 3.5 IN. RT., 3.5 IN. RT.

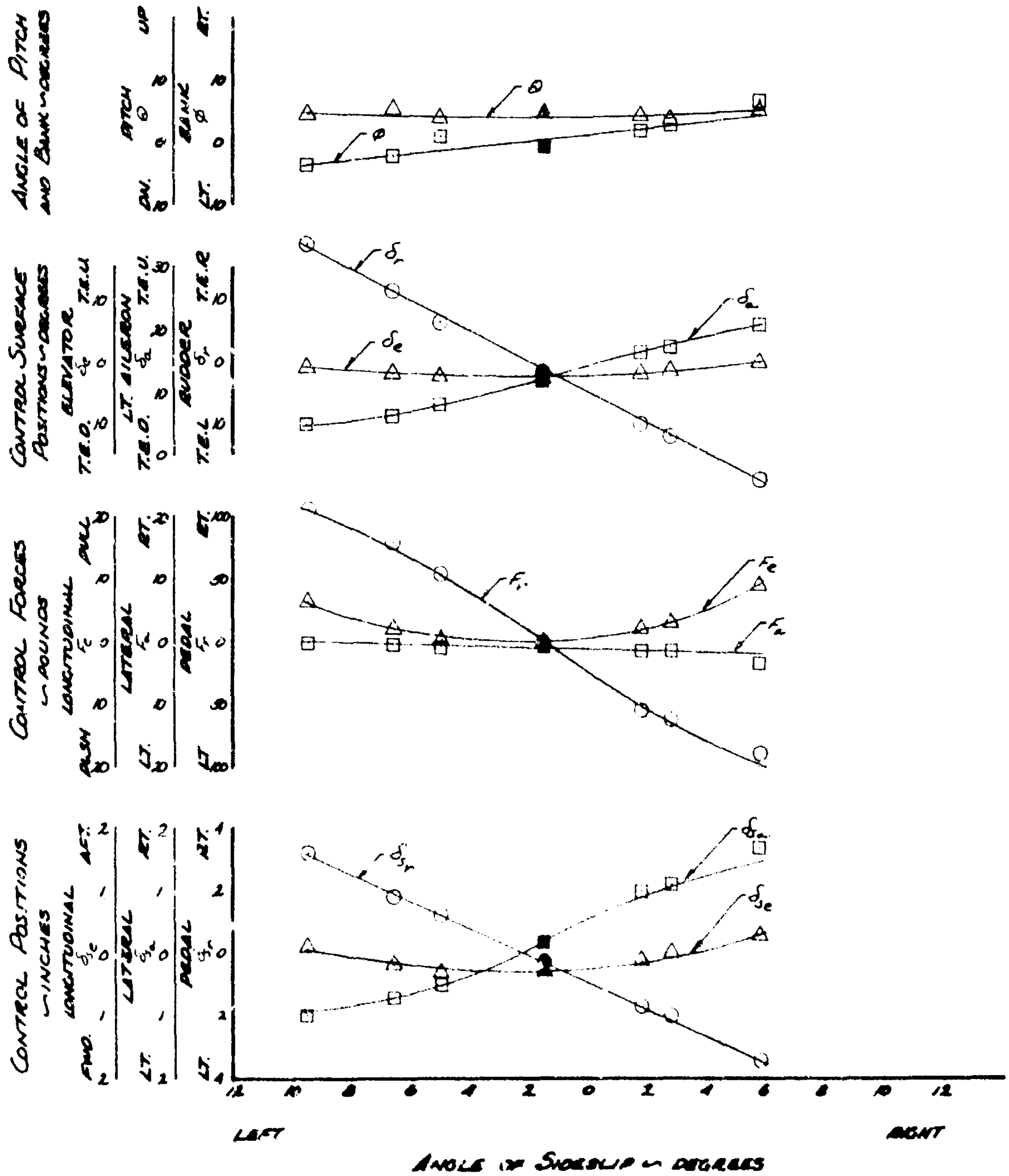


FIGURE No. 105

SUMMARY OF STATIC LONGITUDINAL STABILITY DURING STALL APPROACHES

XV-5A USA S/N 62-4506

JET MODE

SYM	GEAR POS	FLAP POS. $-\delta_f$ ~ % DN	CONFIGURATION
○	DOWN	100	PRE-CONVERSION (P.C.)
□	DOWN	25	POWER APPROACH (P.A.)
△	DOWN	100	POWER APPROACH (P.A.)
◇	UP	100	PRE-CONVERSION (P.C.)

AIRSPEED DECREASED APPROXIMATELY 1 KT/SEC FROM TRIM SPEED.
DATA PRESENTED IS PRIOR TO ANY PRE-STALL BUFFET.
TRIM AIRSPEED = 100 KCAS
AVERAGE PRESSURE ALTITUDE = 14000 FT.

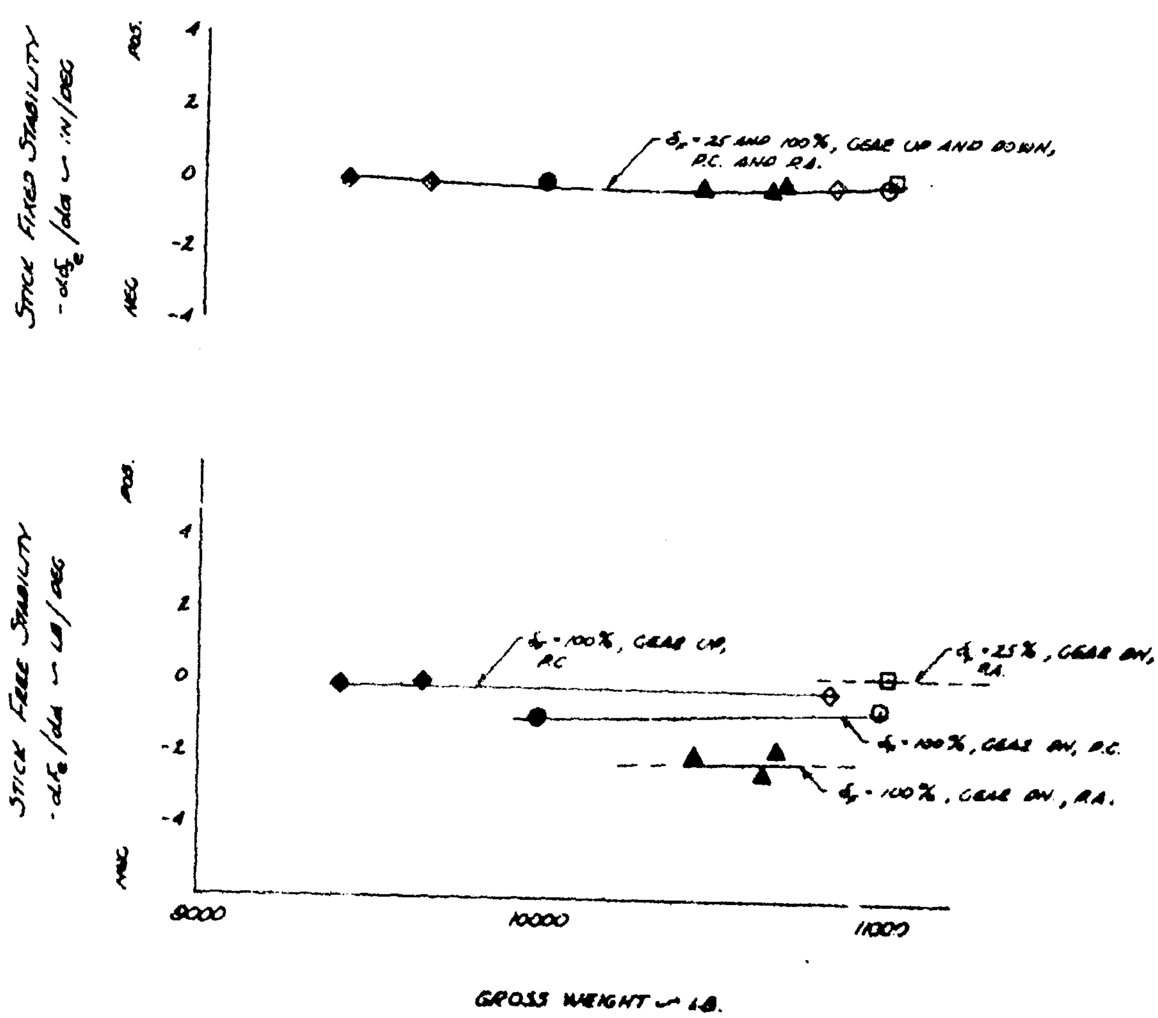


FIGURE NO. 106
SUMMARY OF STATIC LONGITUDINAL
STABILITY DURING STALL APPROACHES
XV-5A USA S/N 62-4506

JET MODE

SYM	GEAR POS.	FLAP POS $-\delta_F$ ~ % DN	CONFIGURATION
○	DOWN	100	PRE-CONVERSION (P.C)
□	DOWN	25	POWER APPROACH (P.A)
△	DOWN	100	POWER APPROACH (P.A)
◇	UP	100	PRE-CONVERSION (P.C)

AIRSPEED DECREASED APPROXIMATELY
1 KT/SEC FROM TRIM SPEED.
DATA PRESENTED IS PRIOR TO ANY
PRE-STALL BUFFET.
TRIM AIRSPEED = 100 KCAS
AVERAGE PRESSURE ALTITUDE = 14000 FT.

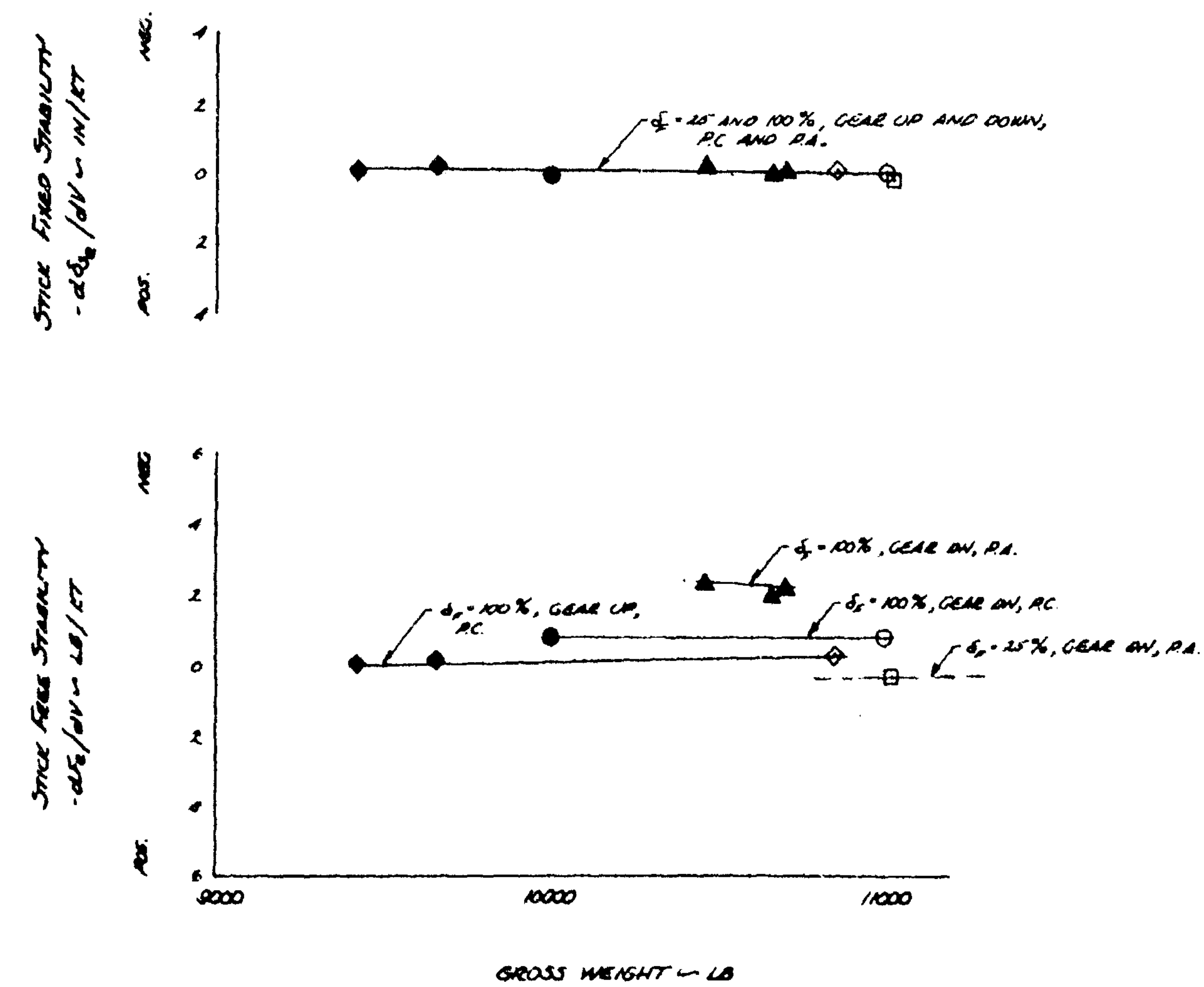


FIGURE No. 107

SUMMARY OF STATIC LONGITUDINAL STABILITY DURING STALL APPROACHES

XV-5A USA S/N 62-4506

JET MODE

SYM	GEAR POS.	FLAP POS $-\delta_f \sim$ % DN	CONFIGURATION
○	DOWN	100	PRE-CONVERSION (P.C.)
□	DOWN	25	POWER APPROACH (P.A.)
△	DOWN	100	POWER APPROACH (P.A.)
◇	UP	100	PRE-CONVERSION (P.C.)

AIRSPEED DECREASED APPROXIMATELY 1 KT/SEC FROM TRIM SPEED.

DATA PRESENTED IS PRIOR TO ANY PRE-STALL BUFFET.

TRIM AIRSPEED = 100 KCAS.

AVERAGE PRESSURE ALTITUDE = 14000 FT.

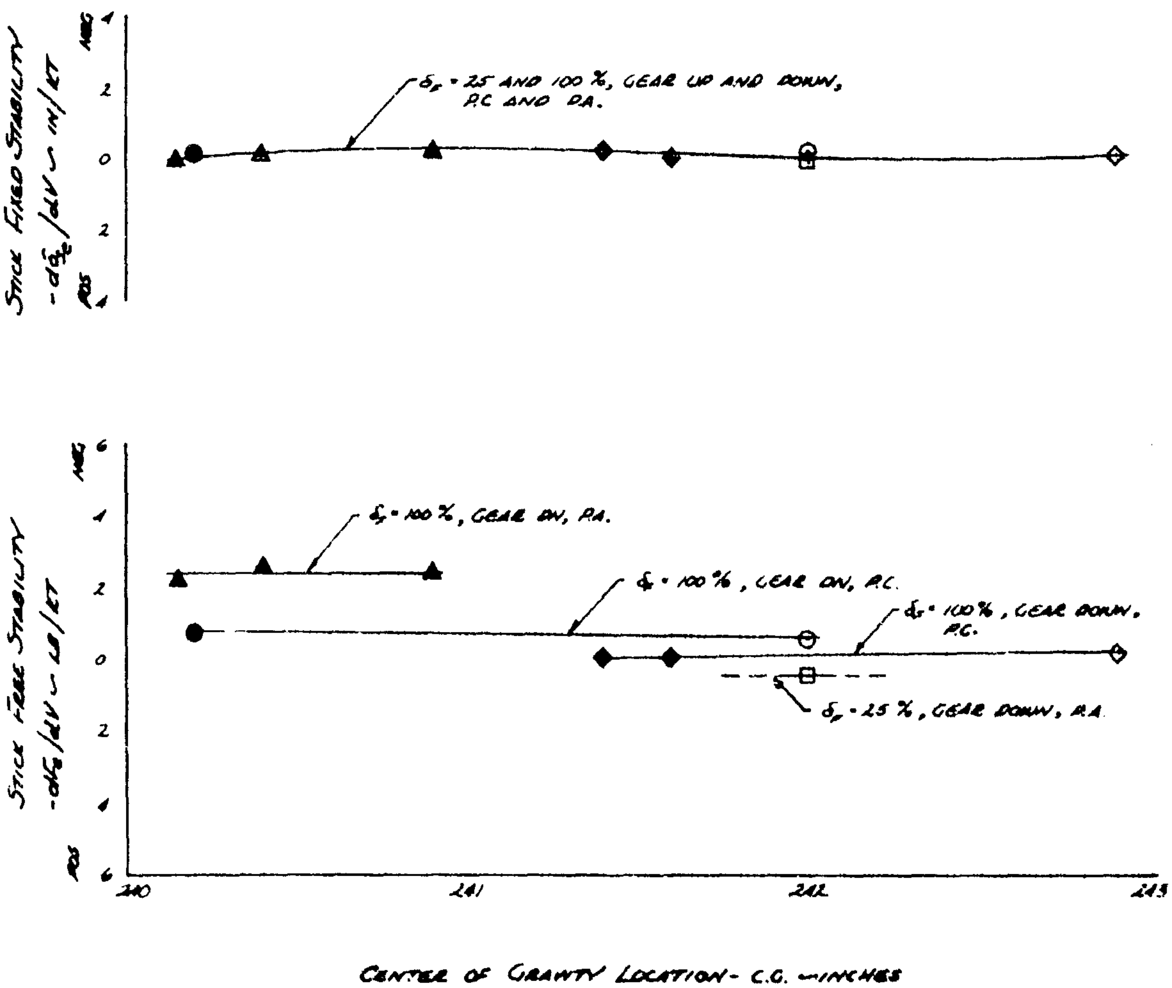


FIGURE No. 108
STALL CHARACTERISTICS
XV-5A USA S/N 62-4506
JET MODE

GROSS WEIGHT = 11500 LB — HOR. STABILIZER POS = 4 DEG. T.E.U.
FLAP POSITION = 12 DEG DN. — CENTER OF GRAVITY LOC. = 242.8 IN.
LANDING GEAR POS = DOWN — POWER APPROACH CONFIGURATION

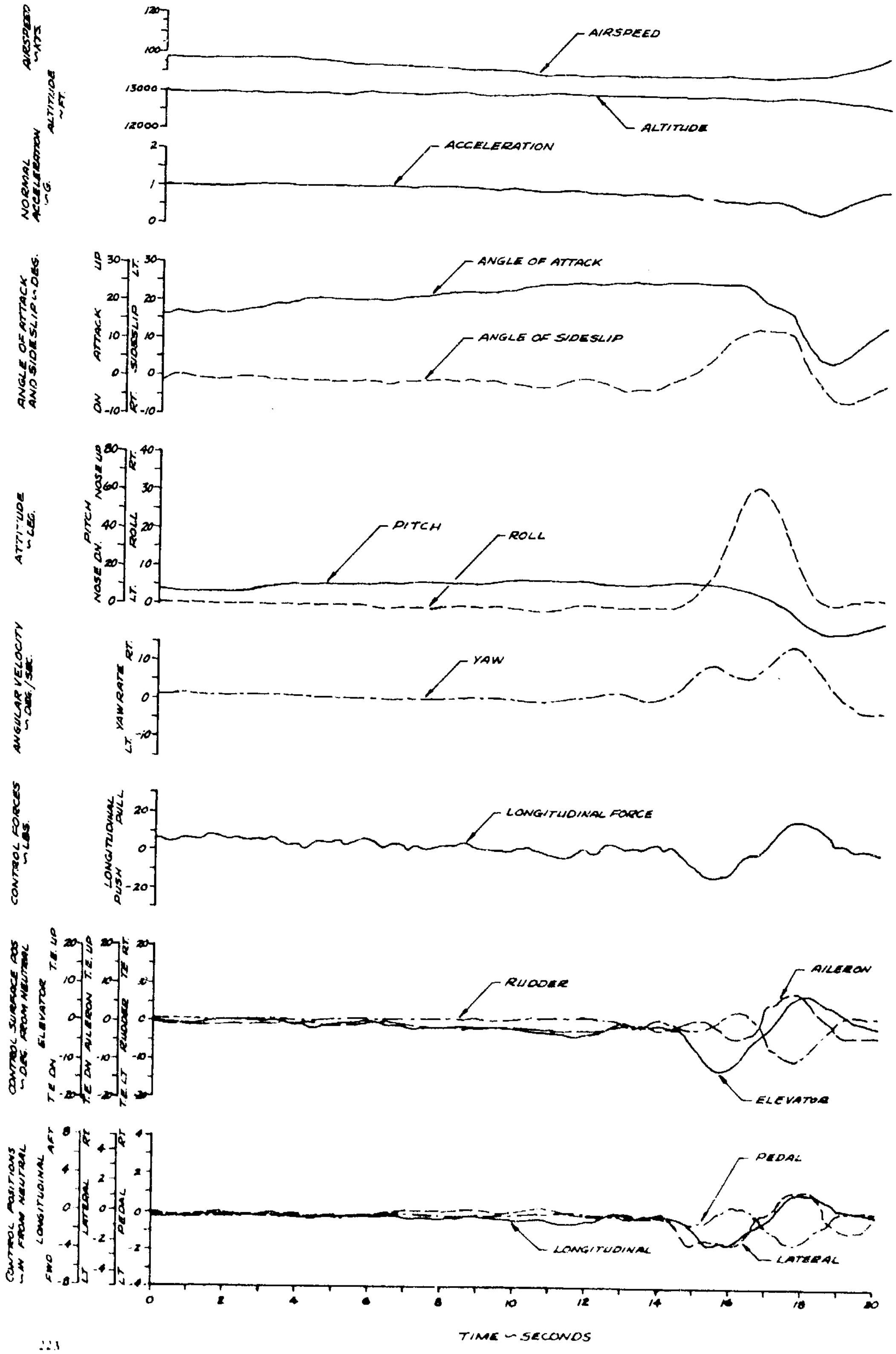


FIGURE No. 109
STALL CHARACTERISTICS
XV-5A USA S/N 62-4506
JET MODE

GROSS WEIGHT = 11200 LB
FLAP POSITION = 45 DEG. DN.
LANDING GEAR POS = DOWN
HOR. STABILIZER POS = 5 DEG. T.E.U.
CENTER OF GRAVITY LOC = 242.1 IN.
PRE-CONVERSION CONFIGURATION

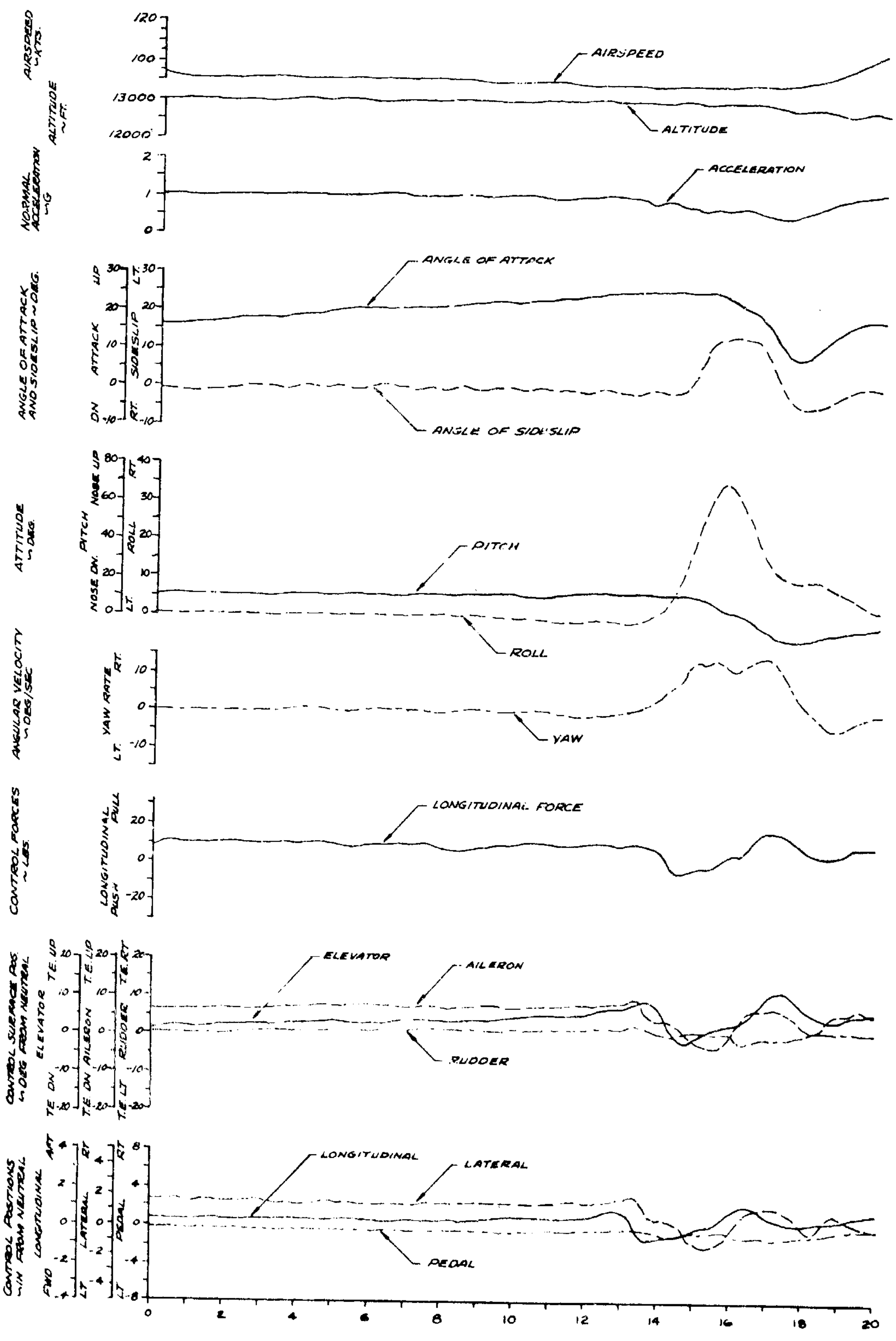


FIGURE No. 110
STALL CHARACTERISTICS
XV-5A USA S/N 62-4506
JET MODE

GROSS WEIGHT = 11000 LB
FLAP POSITION = 45 DEG
LANDING GEAR POS = UP

CENTER OF GRAVITY LOC = 243.0 IN
CONFIGURATION = PRE-CONVERSION
HOR. STABILIZER POS = 5 DEG. T.E.U.

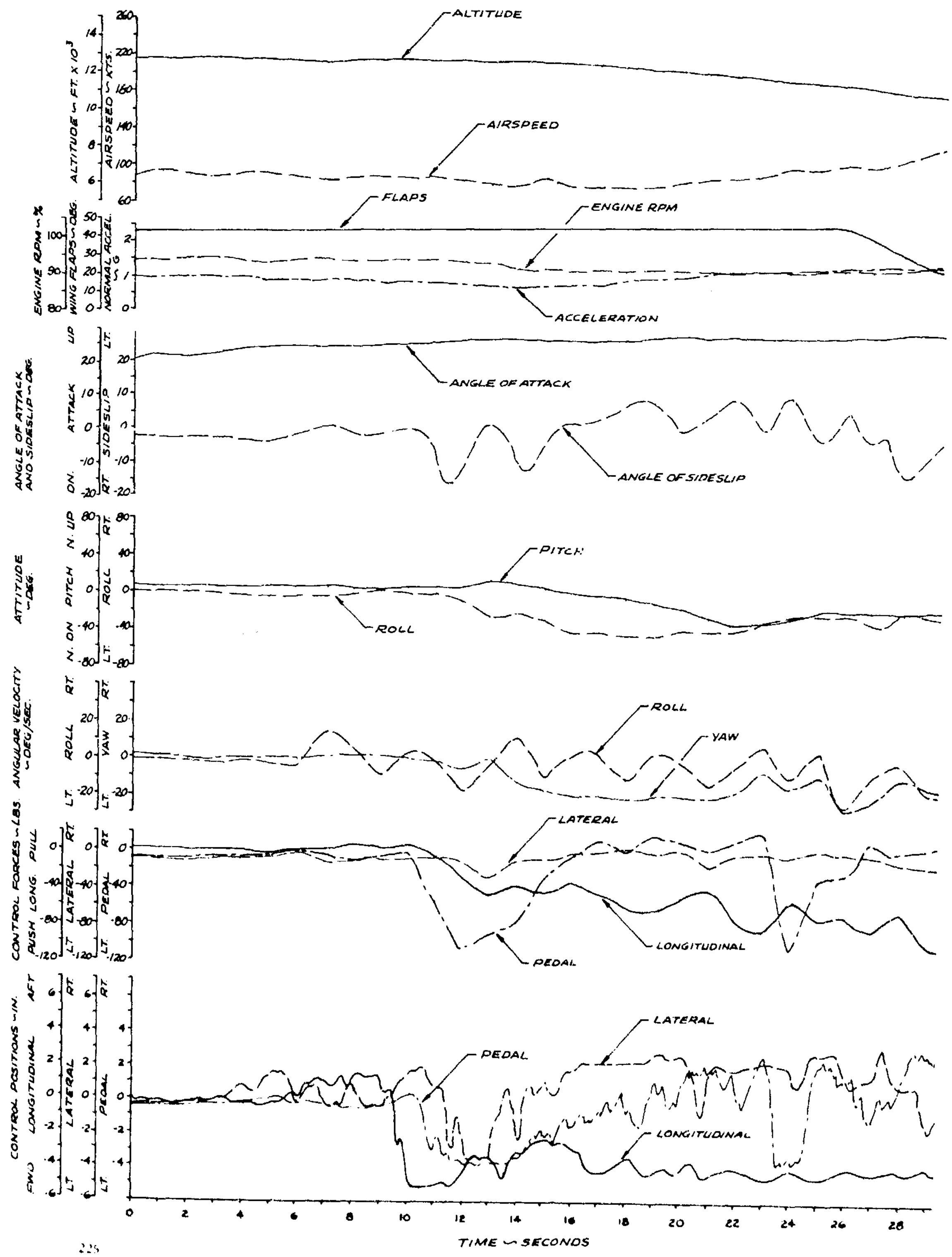


FIGURE No. 110 CONTINUED

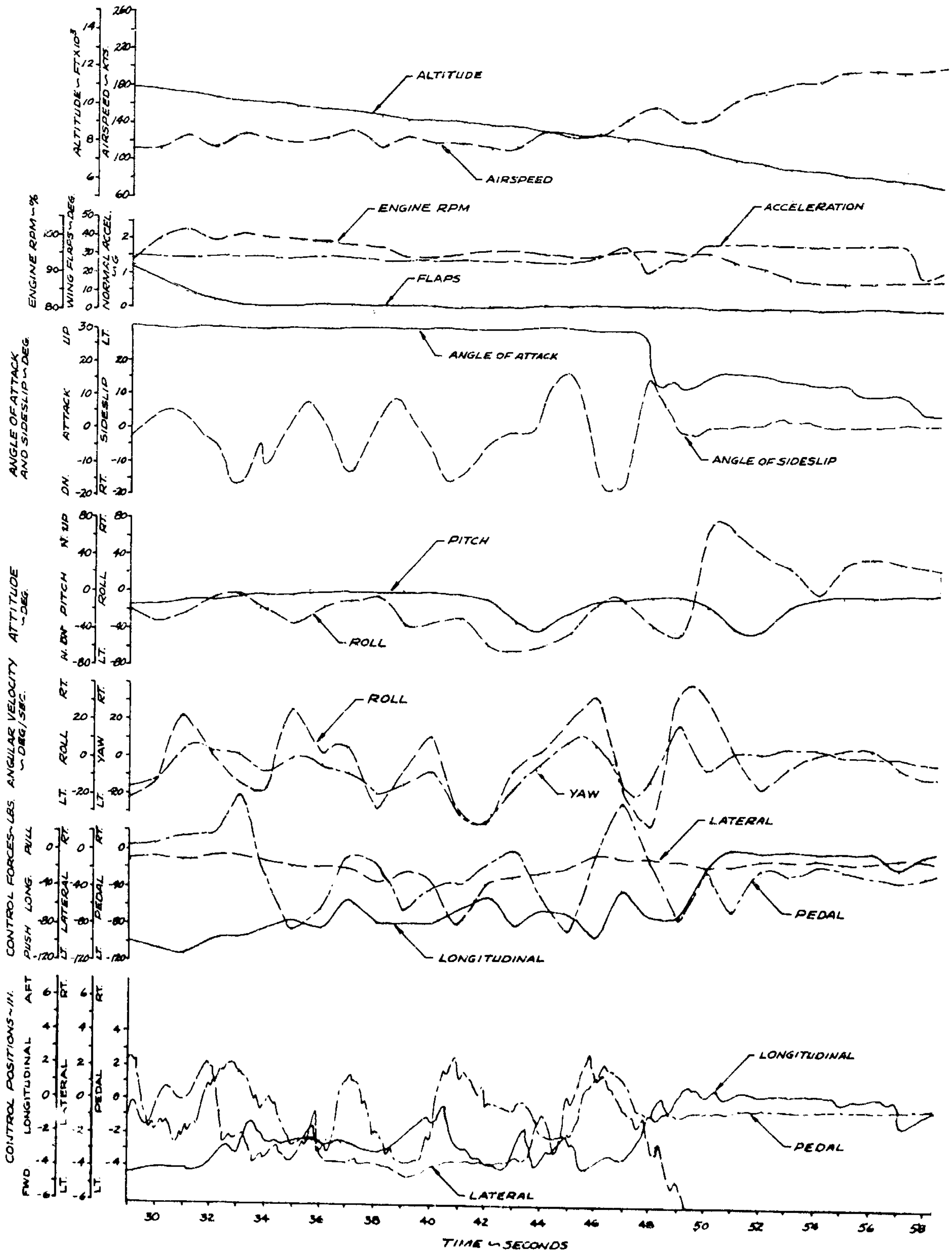


FIGURE No. 111

DYNAMIC LONGITUDINAL STABILITY

XV-5A USA S/N 62-4505

JET MODE

FLT CONDITION = LEVEL FLT
TRIM AIRSPEED = 120 KCAS
LANDING GEAR DOWN
FLAP POSITION = 11 DEG. DN

AVG. PRESSURE ALT = 5600 FT
AVG. G.W = 10220 LB.
AVG. C.G. LOC = 240.3 IN (MAC)
HOR. STABILIZER POS = 3 DEG TE.U.
SAS CONFIG. = INOPERATIVE

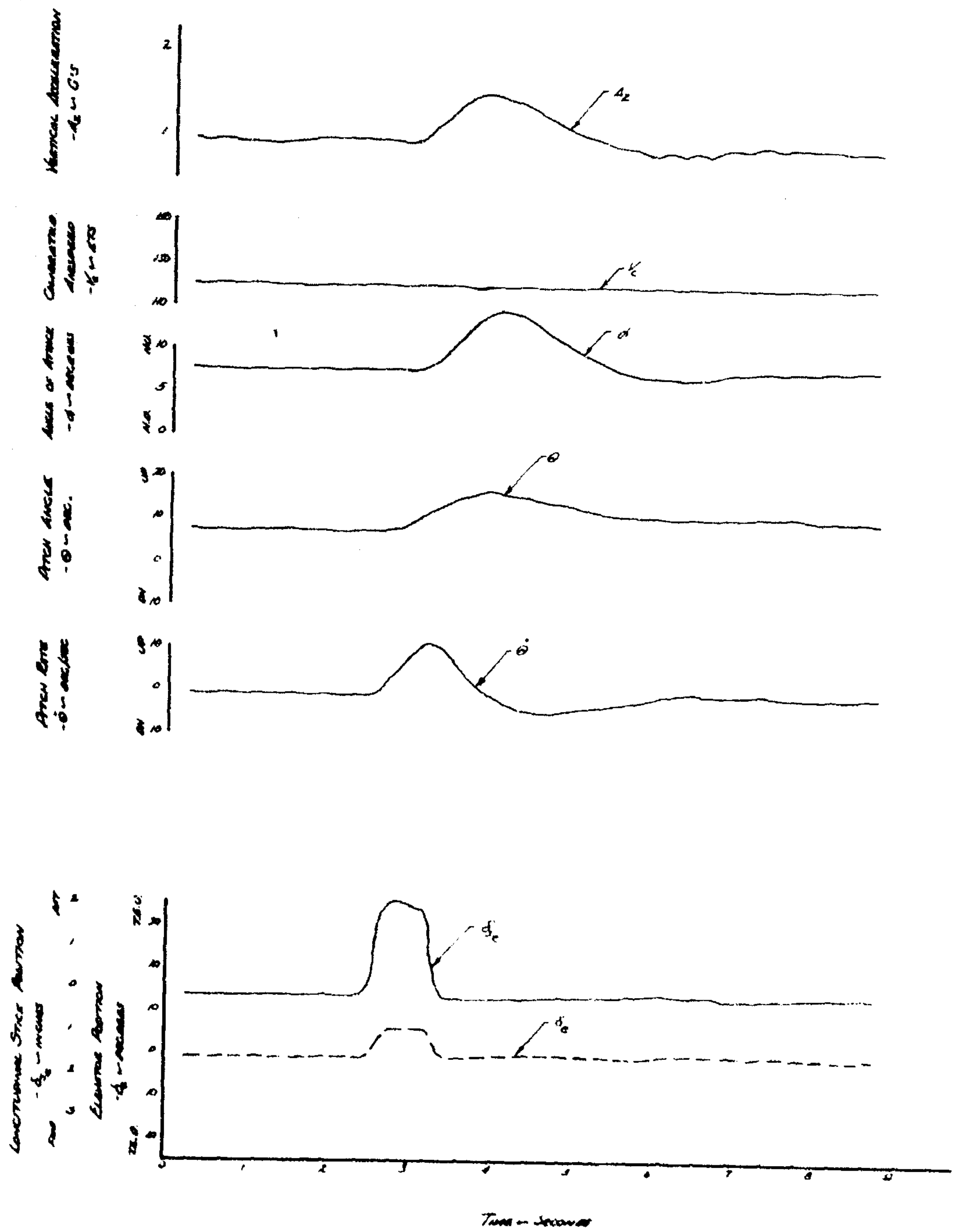


FIGURE NO. 112
DYNAMIC LONGITUDINAL STABILITY
XV-5A USA S/N 62-4505
JET MODE

FLT. CONDITION: LEVEL FLT
TRIM AIRSPEED = 125 KCAS
LANDING GEAR DOWN
AVG PRESSURE ALT. = 9600 FT.
HOR. STABILIZER POS. = 3 DEG. T.E.U

AVG. G.W. = 10 260 LB
AVG. C.G. LOC. = 240.9 IN (MAC)
SAS CONFIG. = INOPERATIVE
FLAP POS. = 11° DOWN

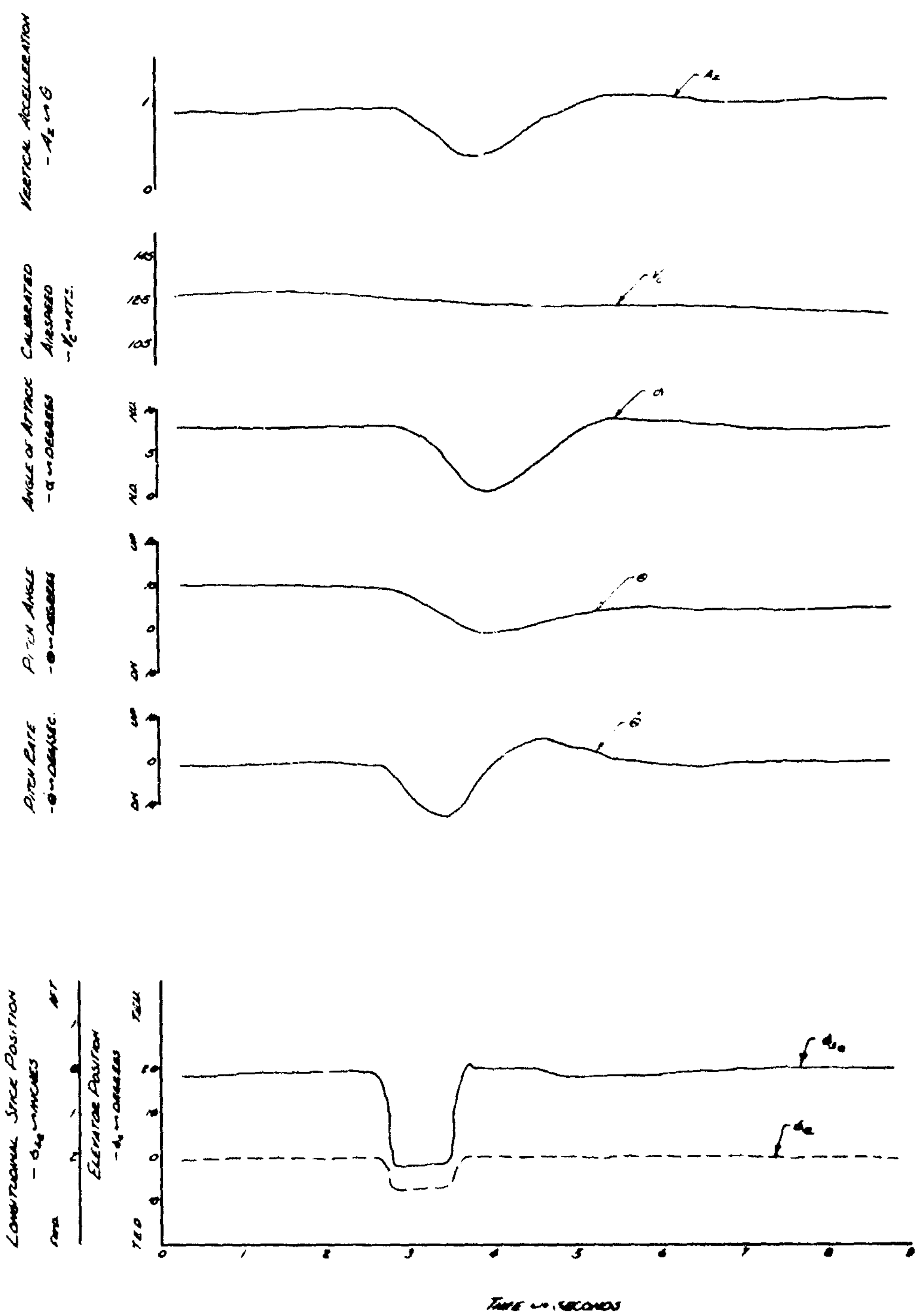


FIGURE NO. 113
DYNAMIC LONGITUDINAL STABILITY
XV-5A USA S/N 62-4505
JET MODE

FLT. CONDITION: LEVEL FLT.
TRIM AIRSPEED = [illegible]5 KCAS
LANDING GEAR UP
FLAP POS. = 0°
HOR. STABILIZER POS. = 2° TEU

AVG. PRESSURE ALT. = 9550 FT
AVG. G.W. = 9900 LB
AVG. C.G. LOC. = 241.8 IN (MID)
SAS CONFIG = INOPERATIVE

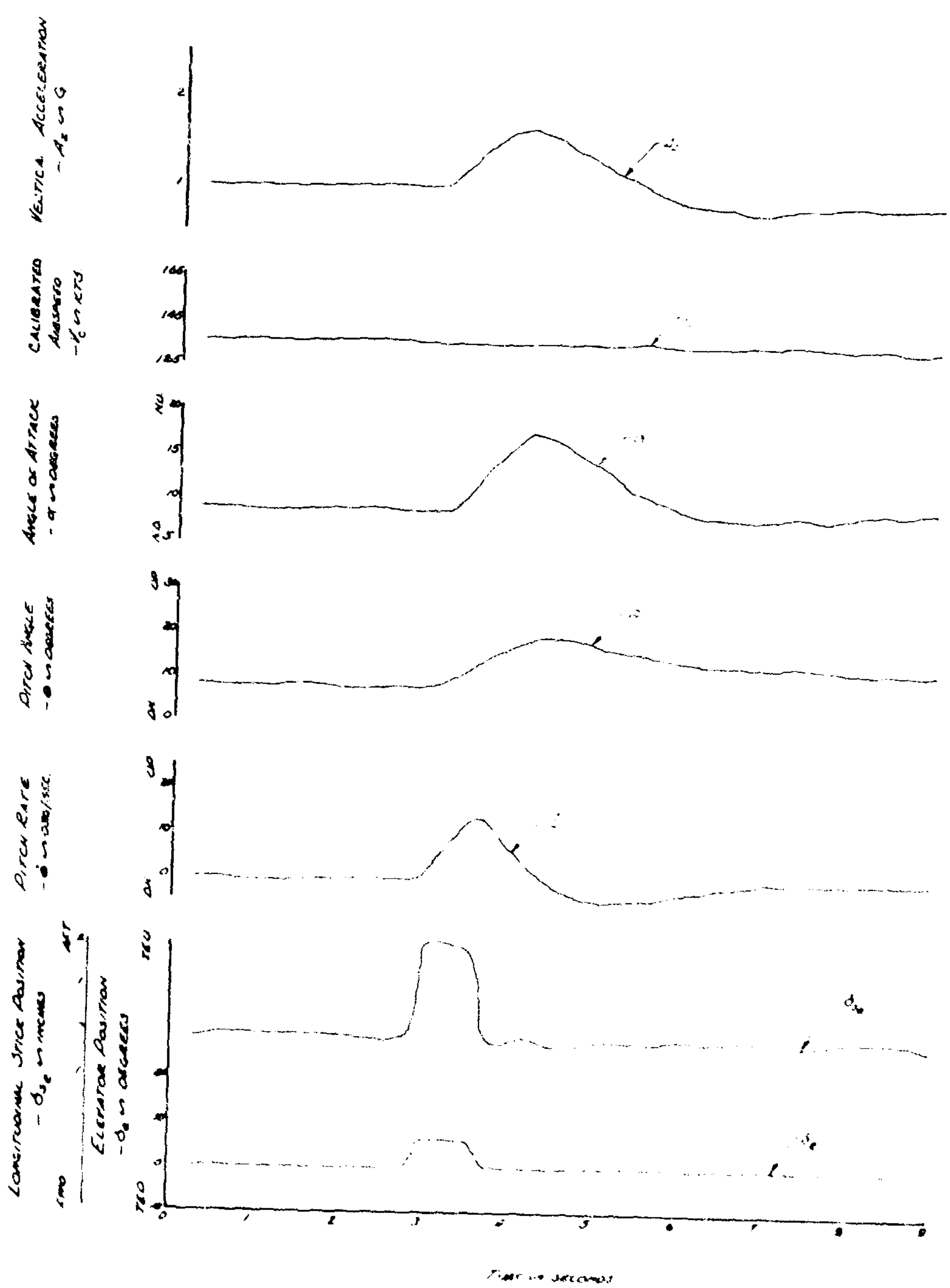


FIGURE No. 114
DYNAMIC LONGITUDINAL STABILITY
XV-5A USA S/N 62-4505
JET MODE

FLT. CONDITION : LEVEL FLT	AVG PRESSURE ALT = 10 200 FT
TRIM AIRSPEED = 137 KCAS	AVG G.W. = 10 240 LB
LANDING GEAR UP	AVG CG LOC = 242.5 IN (MID)
FLAP POS = 0° (UP)	SAS CONFIG = INOPERATIVE
HOR STABILIZER POS = 2° TE U	

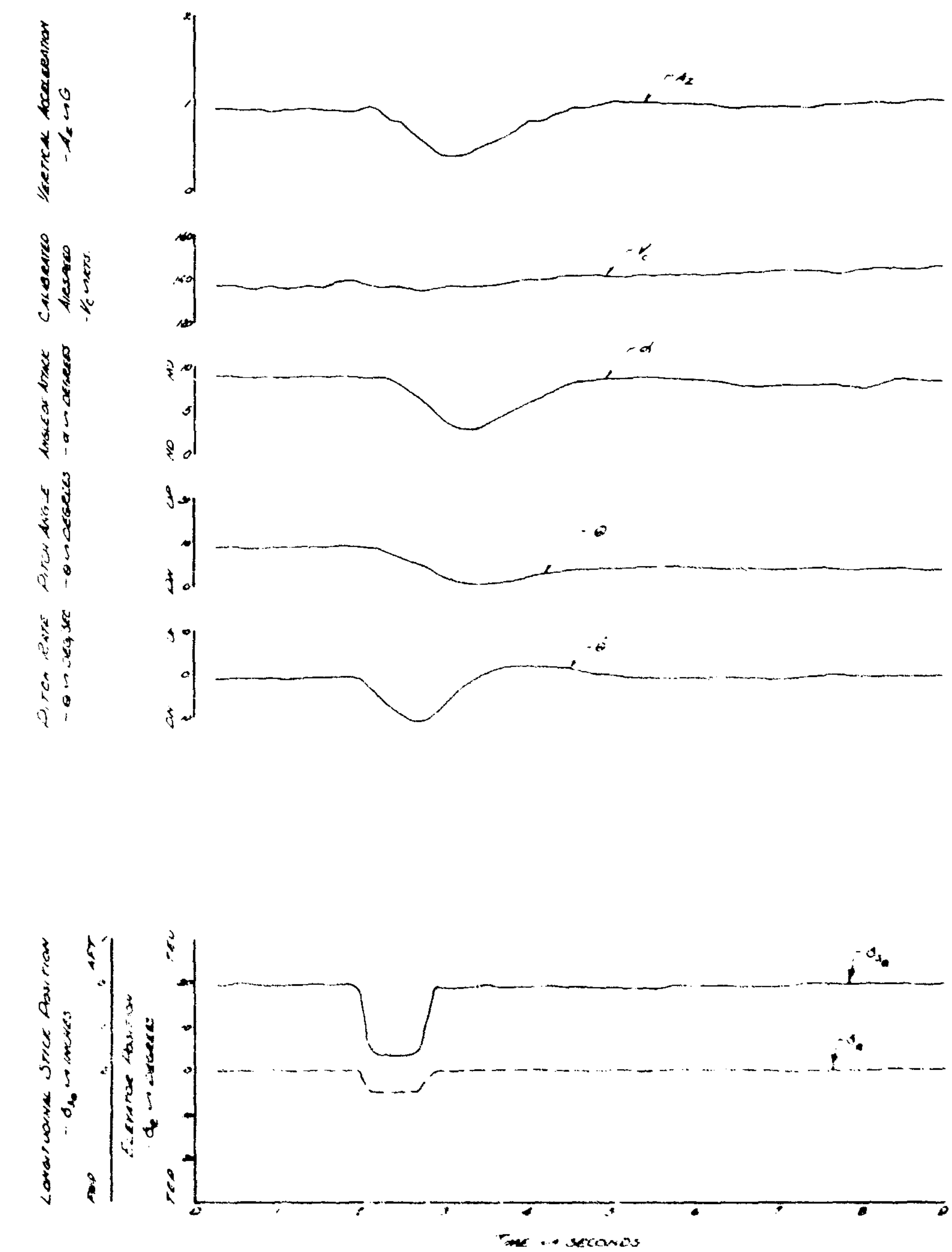


FIGURE No. 115

DYNAMIC LONGITUDINAL STABILITY

XV-5A USA S/N 624505

JET MODE

FLT. CONDITION : LEVEL FLT.
TRIM AIRSPEED = 250 KCAS
LANDING GEAR UP
FLAP POS = 0° (UP)
HOR. STABILIZER POS = 1° T.E.U.

AVG PRESSURE ALT. = 10300 FT
AVG G.W = 10320 LB
AVG C.G. LOC. = 242.5 IN (MID)
SAS CONFIG = INOPERATIVE

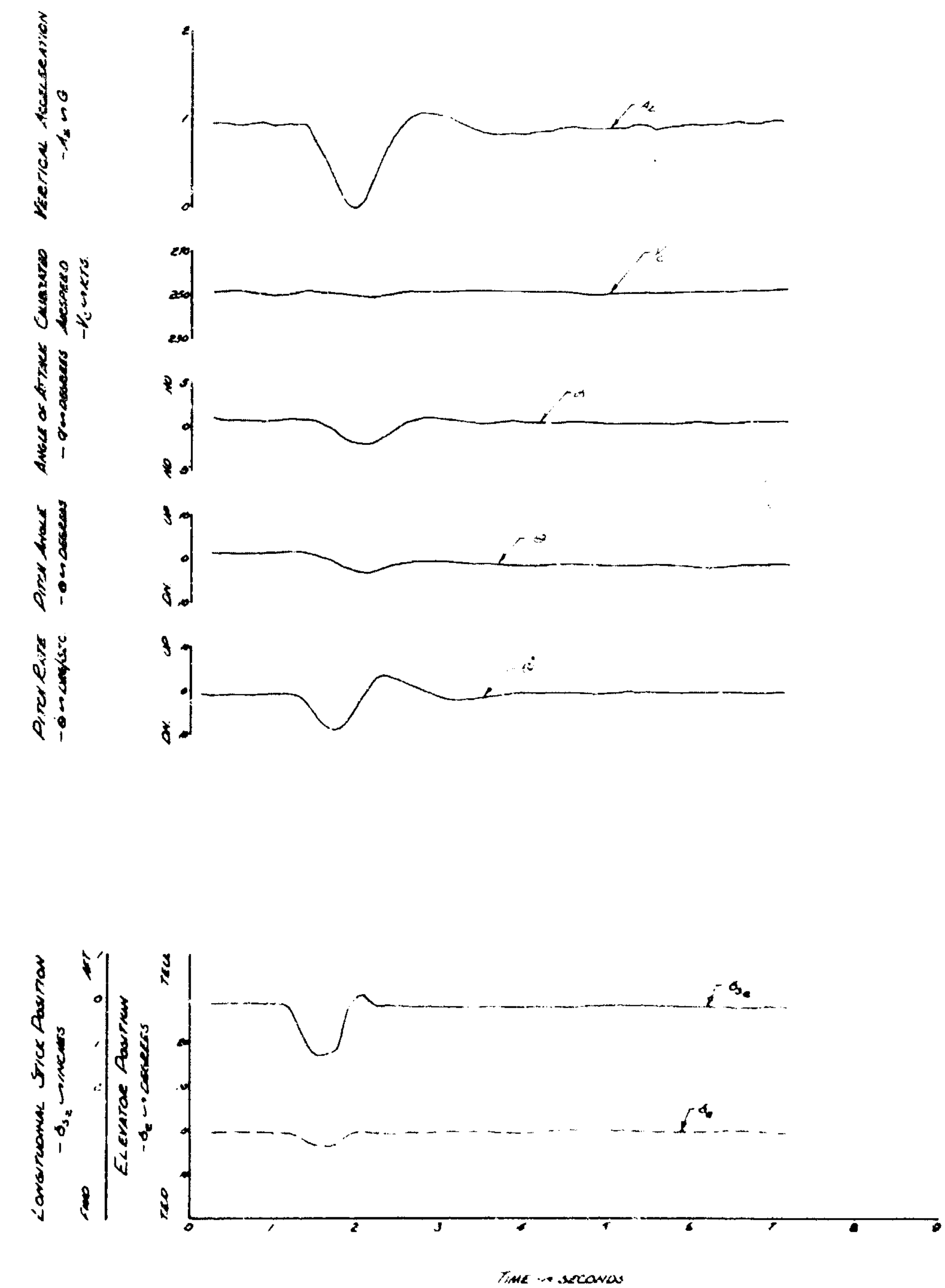


FIGURE No. 116
DYNAMIC LONGITUDINAL STABILITY
XV-5A USA S/N 624505
JET MODE

FLT CONDITION : LEVEL FLT.
TRIM AIRSPEED = 256 KCAS
LANDING GEAR UP
FLAP POS. = 0° (UP)
HOR STABILIZER POS = 1° T.E.U

AVG PRESSURE ALT = 9640
AVG GW = 10780 LB
AVG C.G. = 242.2 IN (MAC)
SAS CONFIG = INOPERATIVE

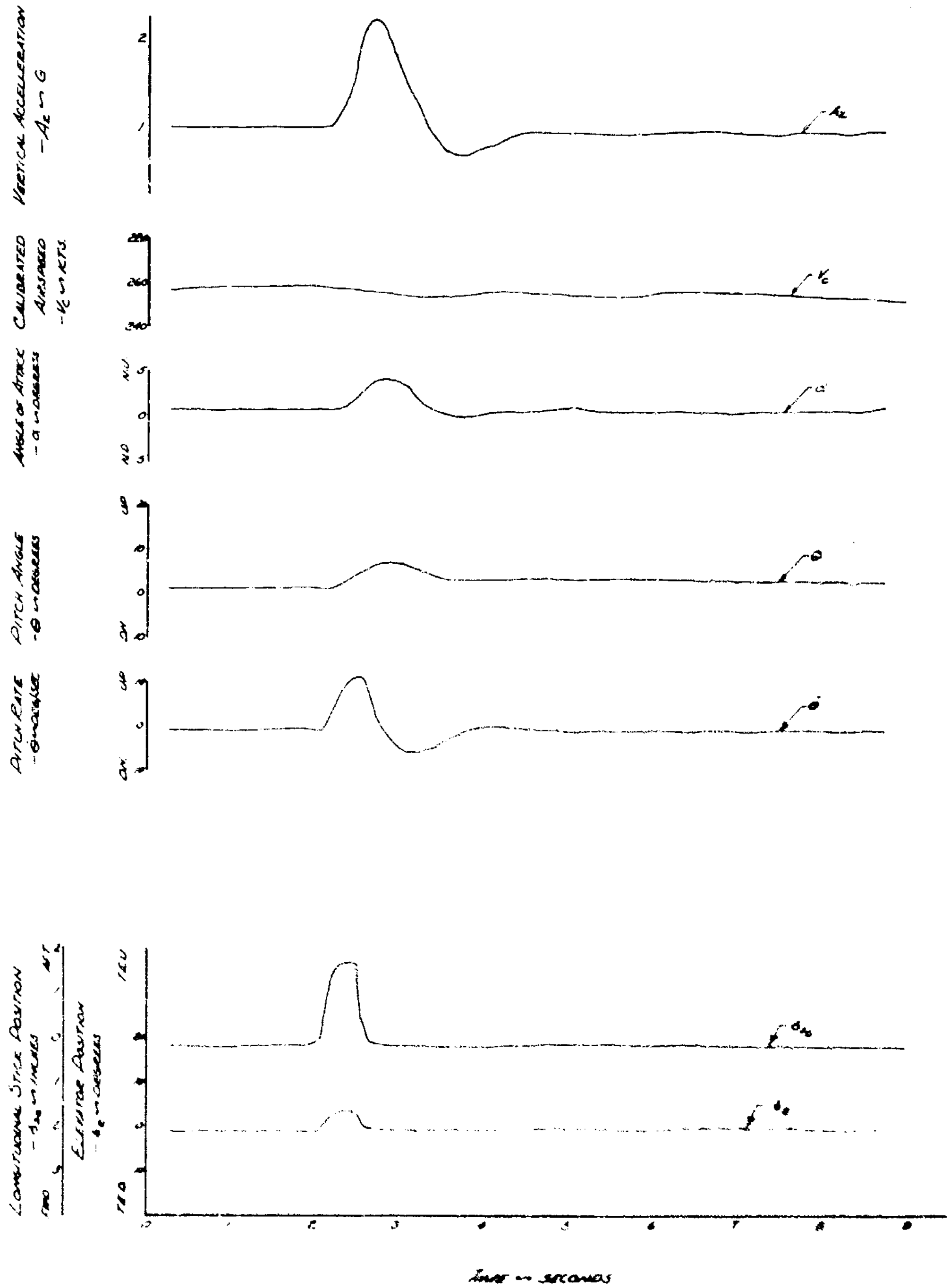


FIGURE No. 117
DYNAMIC LATERAL-DIRECTIONAL STABILITY
XV-5A USA S/N 62-4505
JET MODE PRE-COVERSION

FLT CONDITION : LEVEL FLT
TRIM AIRSPEED = 105 KCAS
AVG PRESSURE ALT = 5170 FT
HOR STABILIZER POS. = 3° T.E.U.

AVG GW = 10 720 LB
AVG CG LOC. = 240.6 IN (MID)
SAS CONFIG = INOPERATIVE

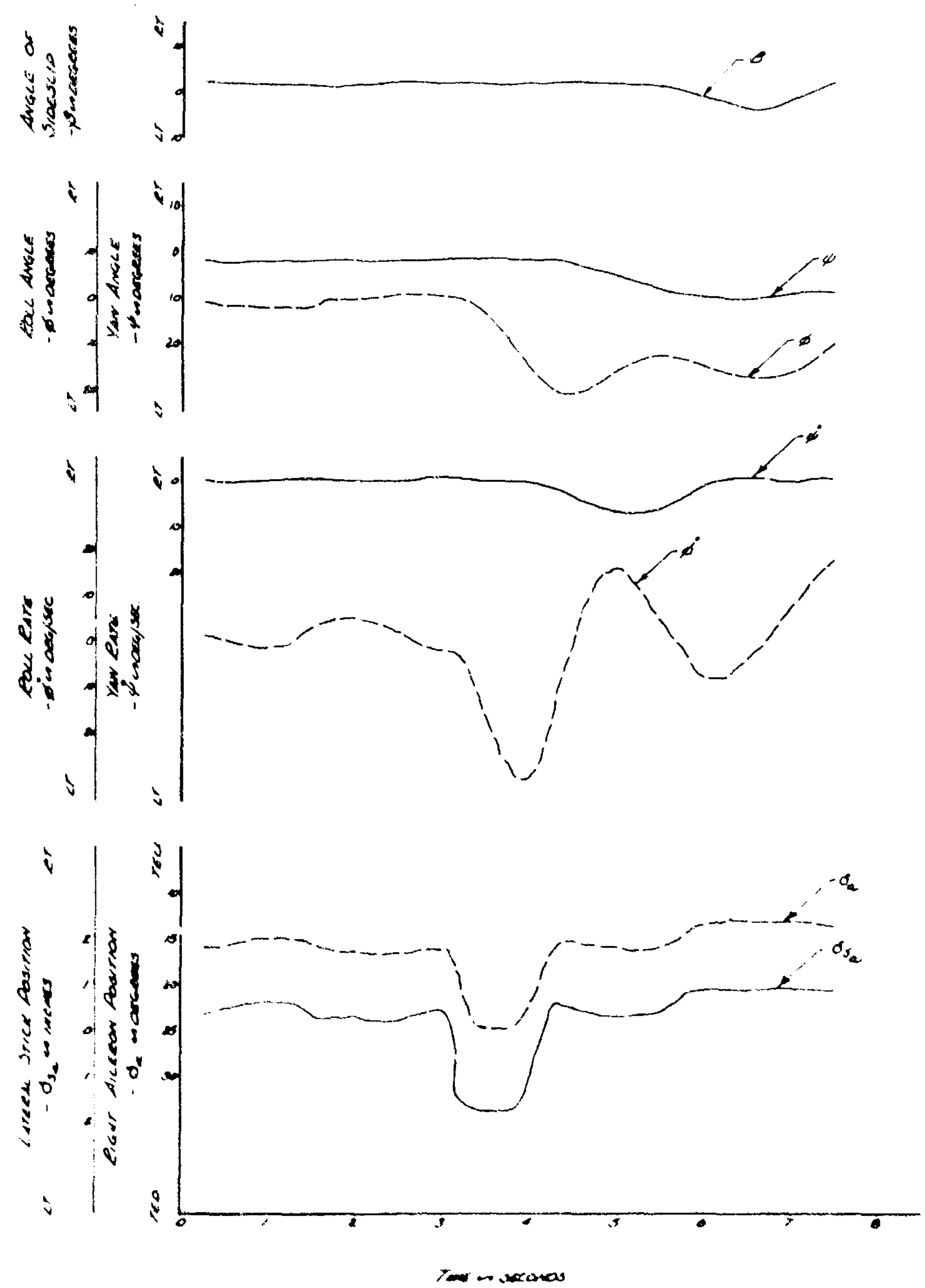


FIGURE No. 118
DYNAMIC DIRECTIONAL STABILITY
XV-5A USA S/N 624505
JET MODE PRE-CONVERSION

FLT. CONDITION : LEVEL FLT.
TRIM AIRSPEED = 107 KCAS
AVG PRESSURE ALT. = 5060 FT
HOR. STABILIZER POS = 3° T.E.U.

AVG G.W. = 10640 LB
AVG C.G. LOC. = 240.6 IN (MID)
SAS CONFIG. = INOPERATIVE

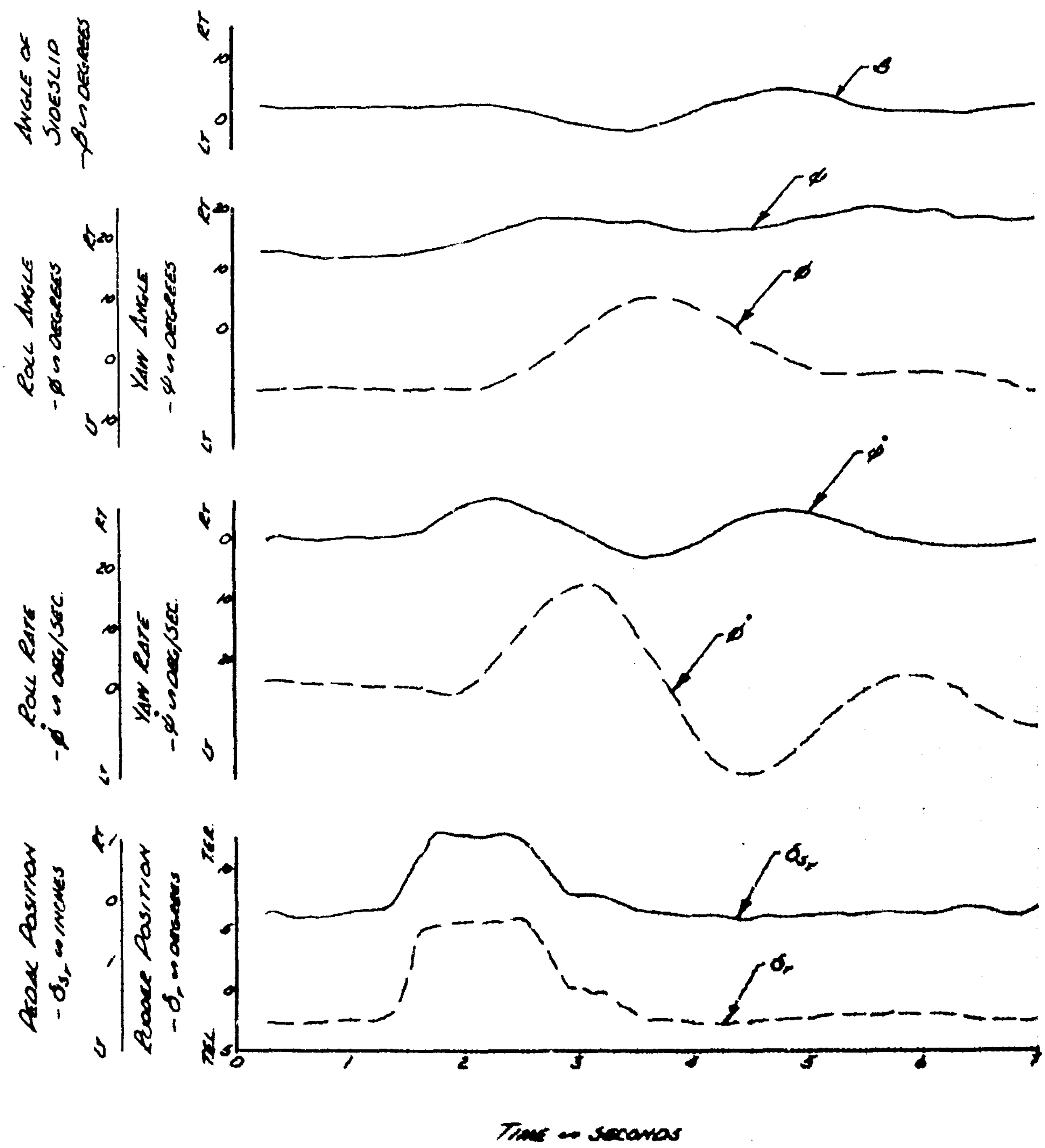
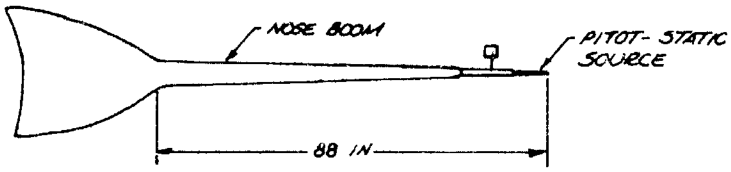


FIGURE No. 119
AIRSPEED CALIBRATION
XV-5A USA S/N 624505
JET MODE
LOW AIRSPEED SYSTEM - NOSE BOOM

SYM	AVG ALT $-H_p$ ~ FT.	AVG. G.W. ~ LB	CONFIG	FLAP POS ~ DEG.	GEAR POS.	AVG C.G. LOC ~ IN
○	4970	10260	PRE-CONV.	45	UP	242.1 (MID)
□	9970	10120	POWER APP.	45	UP	242.1 (MID)
◇	10000	10010	CRUISE	0	UP	242.2 (MID)
△	5100	10390	PRE-CONV.	45	DN	240.6 (MID)



CALIBRATION FROM PACER TECHNIQUE
PACE AIRCRAFT T-37 S/N 492
CALIBRATED AIRSPEED EQUALS CORRECTED AIRSPEED PLUS POSITION ERROR
$V_c = V_{ic} + \Delta V_{P.C.}$

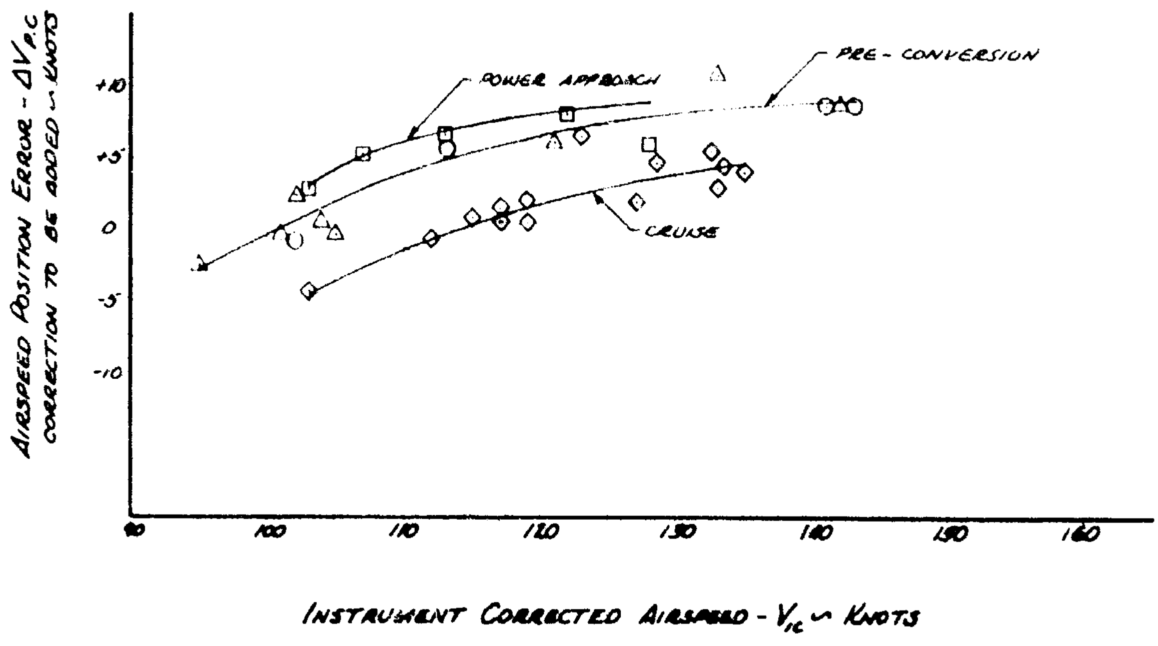
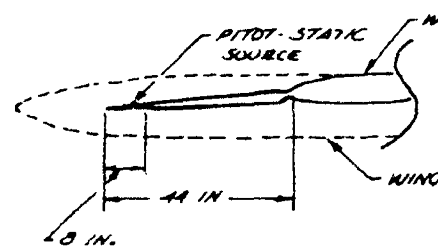


FIGURE No. 120
AIRSPEED CALIBRATION
XV-5A USA S/N 624505
HIGH AIRSPEED SYSTEM - WING BOOM
JET MODE

SYM	AVG ALT $-H_p$ ~FT.	AVG. G.W. ~LB	CONFIG.	GEAR POS	AVG C.G LOC~IN.	FLAP POS ~DEG
○	4970	10260	PRE-CONVERSION	UP	242.1(MID)	45
□	9970	10120	POWER APPROACH	UP	242.1(MID)	45
◇	10000	10010	CRUISE	UP	242.2(MID)	0



◇ DENOTES CONTRACTOR DATA FROM PHASE I PROGRAM.

ALL PACER DATA FROM T-37 AIRCRAFT S/N 492.

CALIBRATED AIRSPEED EQUALS CORRECTED AIRSPEED PLUS POSITION ERROR
$V_c = V_{ic} + \Delta V_{P.C.}$

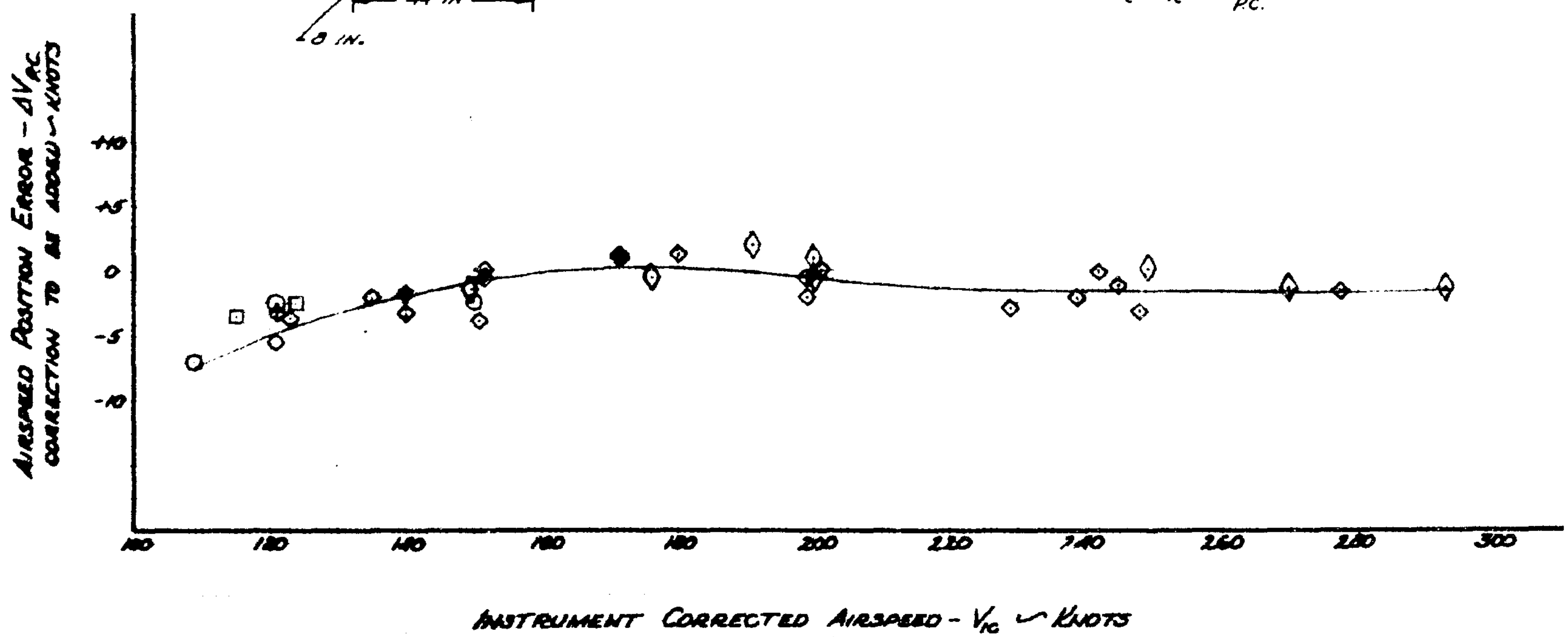


FIGURE No. 121

FAN MODE VERTICAL CLIMB

XV-5A USA S/N 62-4505

FLAP POSITION = 45 DEG.
GEAR POSITION = DOWN
BETA VECTOR ANG = 7 DEG. FWD.
HOR STAB POS = .10 DEG T.E.D.

AVG. G.W = 10650 POUNDS
AVG. C.G. LOCATION = 239.9 (MID)
SAS CONFIGURATION - OPTIMUM

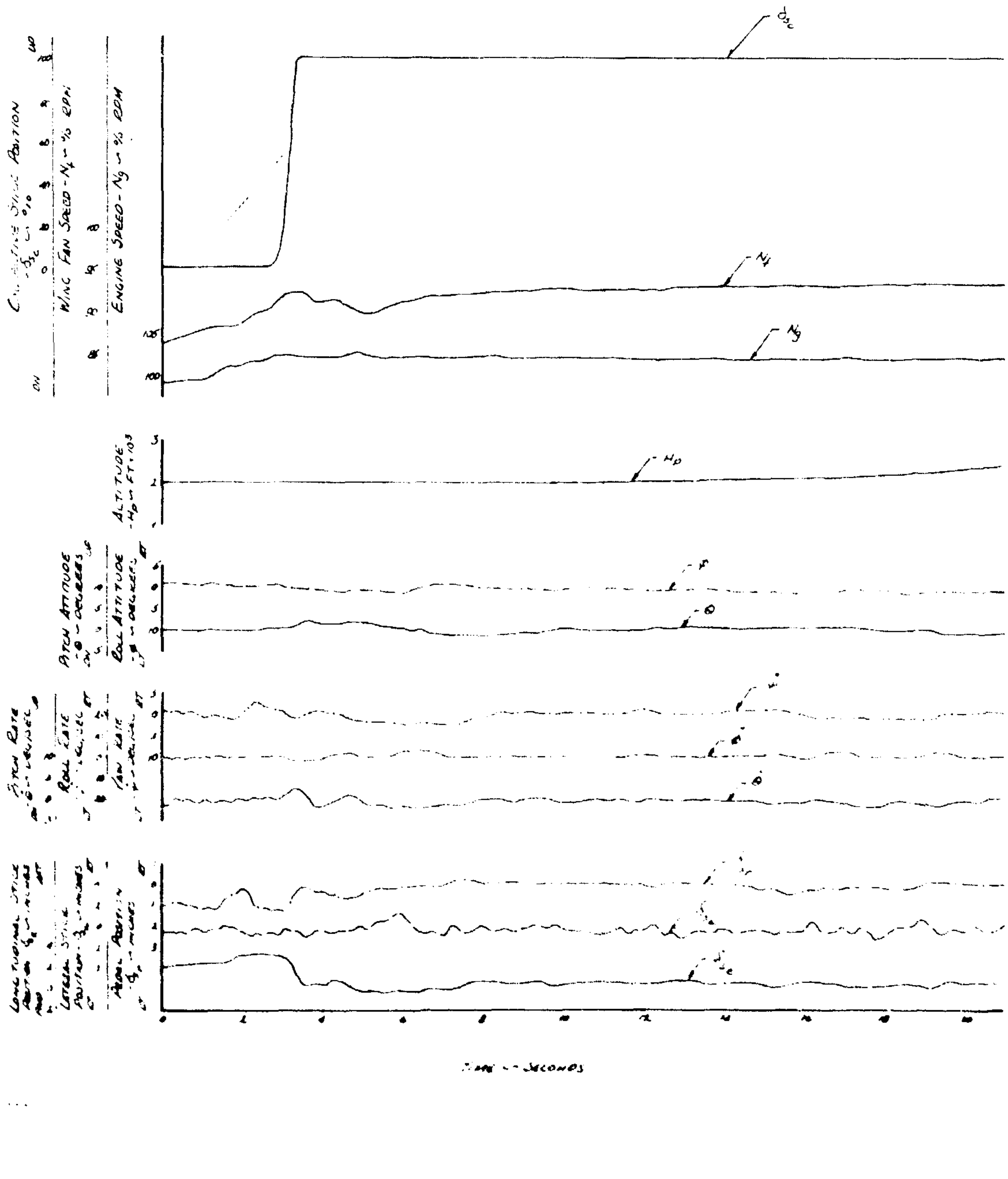


FIGURE No. 121 CONTINUED

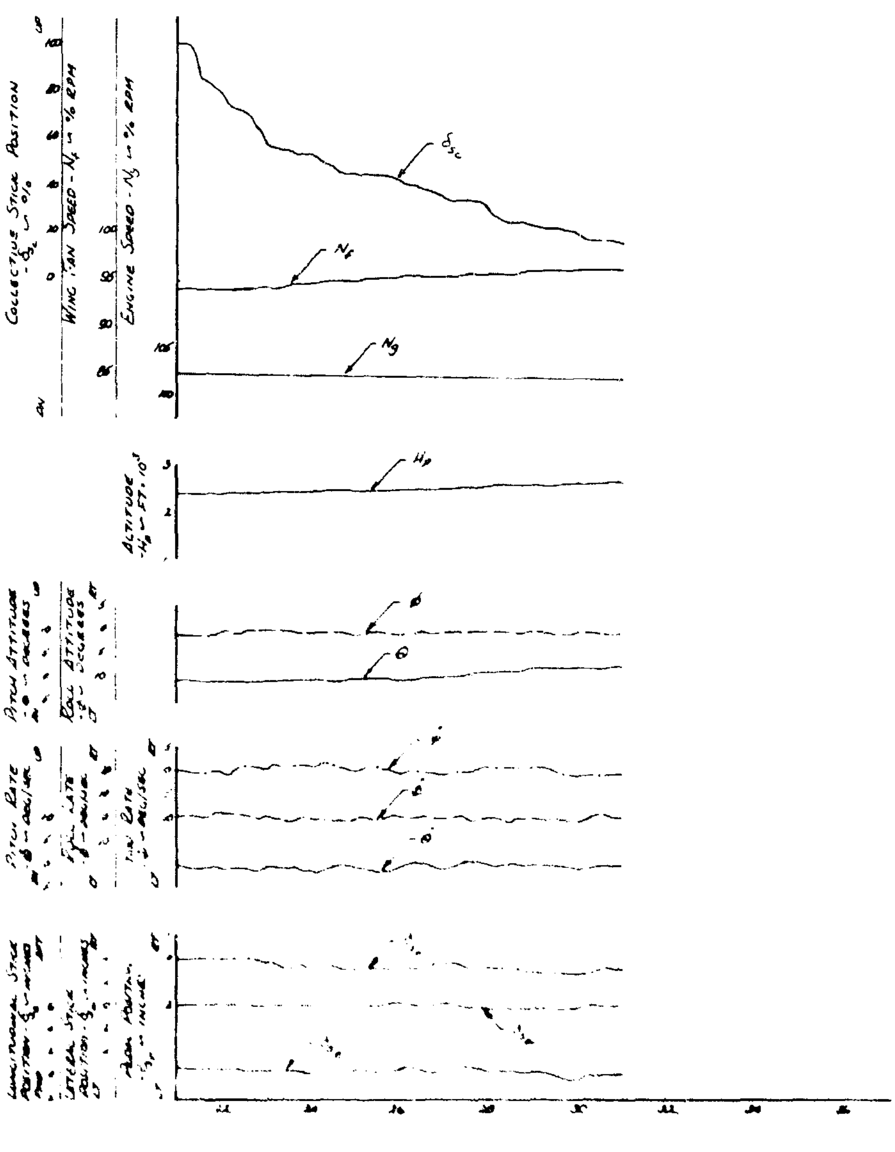


FIGURE No. 122

FAN MODE VERTICAL DESCENT

XV-5A USA S/N 62-4505

FLAP POSITION = 45 DEG
GEAR POSITION = DOWN
BETA VECTOR ANG = 7 DEG FWD
HOR. STAB. POS = 20 DEG T.E.D.

AVG. G.W. = 10750 POUNDS
AVG. C.G. LOC = 239.9(MID)
SAS CONFIG = OPTIMUM

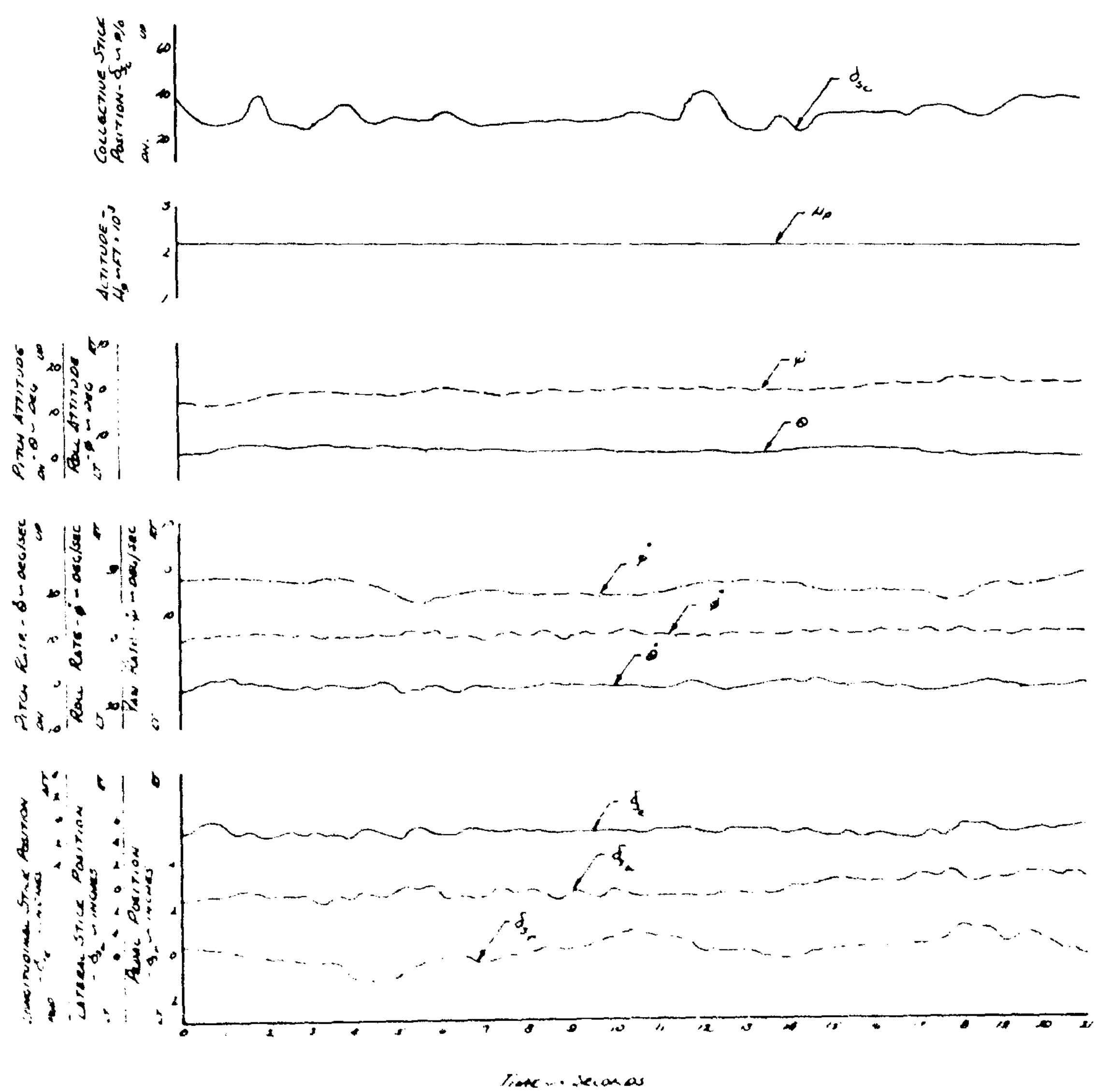


FIGURE No. 123

HOVER AT A WHEEL HEIGHT OF FIFTY FEET

XV-5A USA S/N 62-4505

FLAP POSITION = 45 DEG
GEAR POSITION = DOWN
BETA VECTOR ANG = 8.7 DEG FWD
HOR. STAB. POS = 20 DEG. T.E.D.

AVG. PRESSURE ALT = 2300 FT.
AVG. G.W = 10840 POUNDS
AVG. C.G. LOC = 240.1 IN(MID)
SAS CONFIG = OPTIMUM

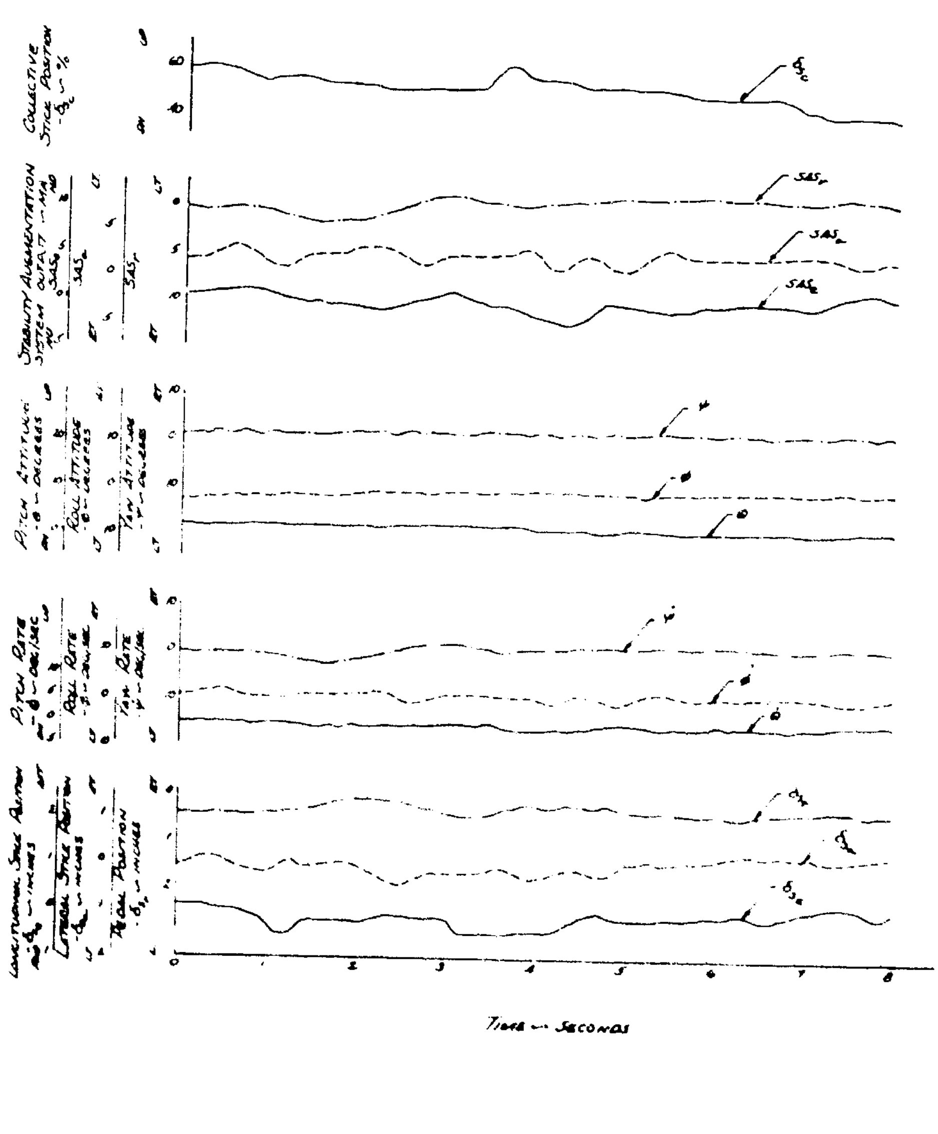


FIGURE NO. 124

HOVER AT A WHEEL HEIGHT OF FIVE FEET

XV-5A — USA S/N 62-4505

FLAP POSITION = 45 DEG.
GEAR POSITION = DOWN
BETA VECTOR ANGLE = 8.7 DEG. FWD.
HOR. STAB POS. = 20 DEG T.E.D.

AVG PRESSURE ALT = 2340 FT.
AVG G.W. = [illegible] POUNDS.
AVG C.G. LOC = 240.1 IN (MID).
SAS CONFIG = OPTIMUM.

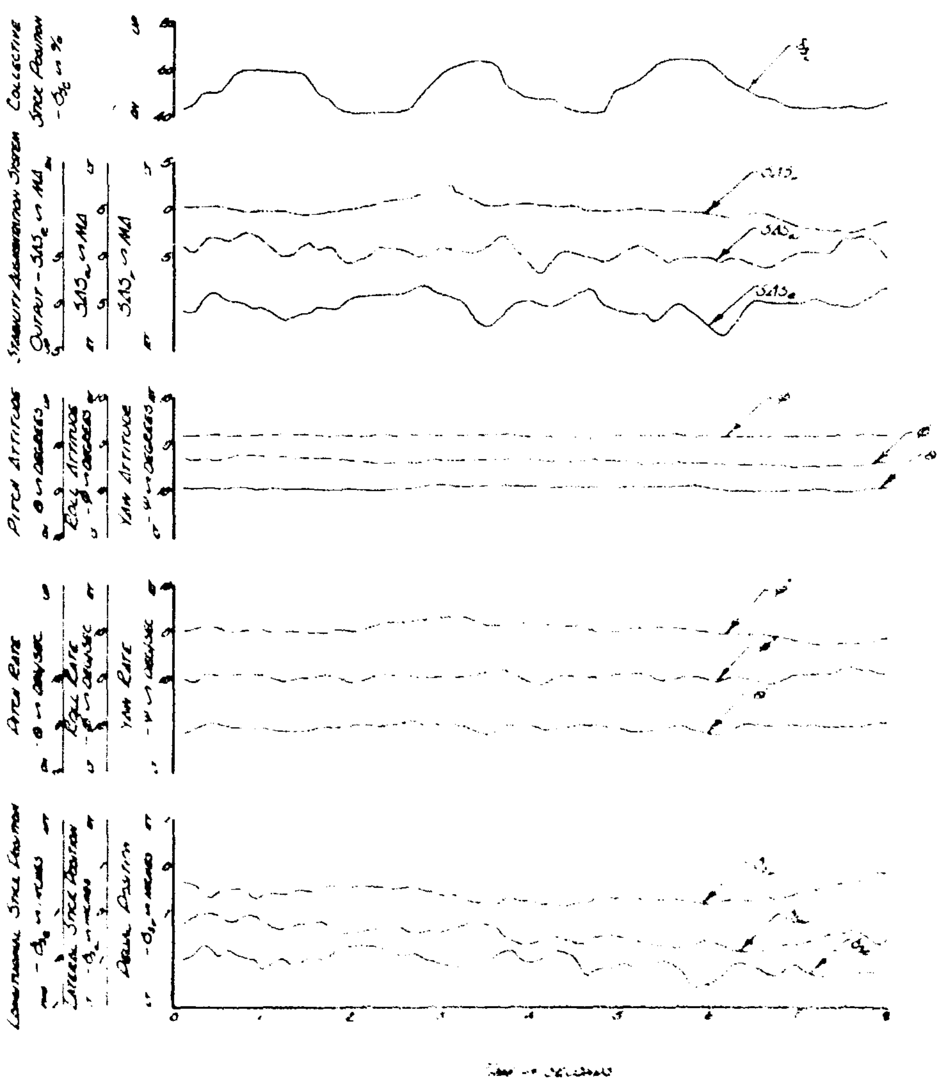


Figure No. 125

HOVER AT A WHEEL HEIGHT OF THREE FEET

XV-5A USA % 62-4505

FLAP POSITION = 45 DEG
GEAR POSITION = DOWN
BETA VECTOR ANG = 8.1 DEG. FWD.
HOR. STAB. POS = 20 DEG. T.E. D.

AVG. PRESSURE ALT = 2340 FT.
AVG. G.W. = 10140 POUNDS
AVG. C.G. LOC = 240.1 IN. (MID)
SAS CONFIG = OPTIMUM

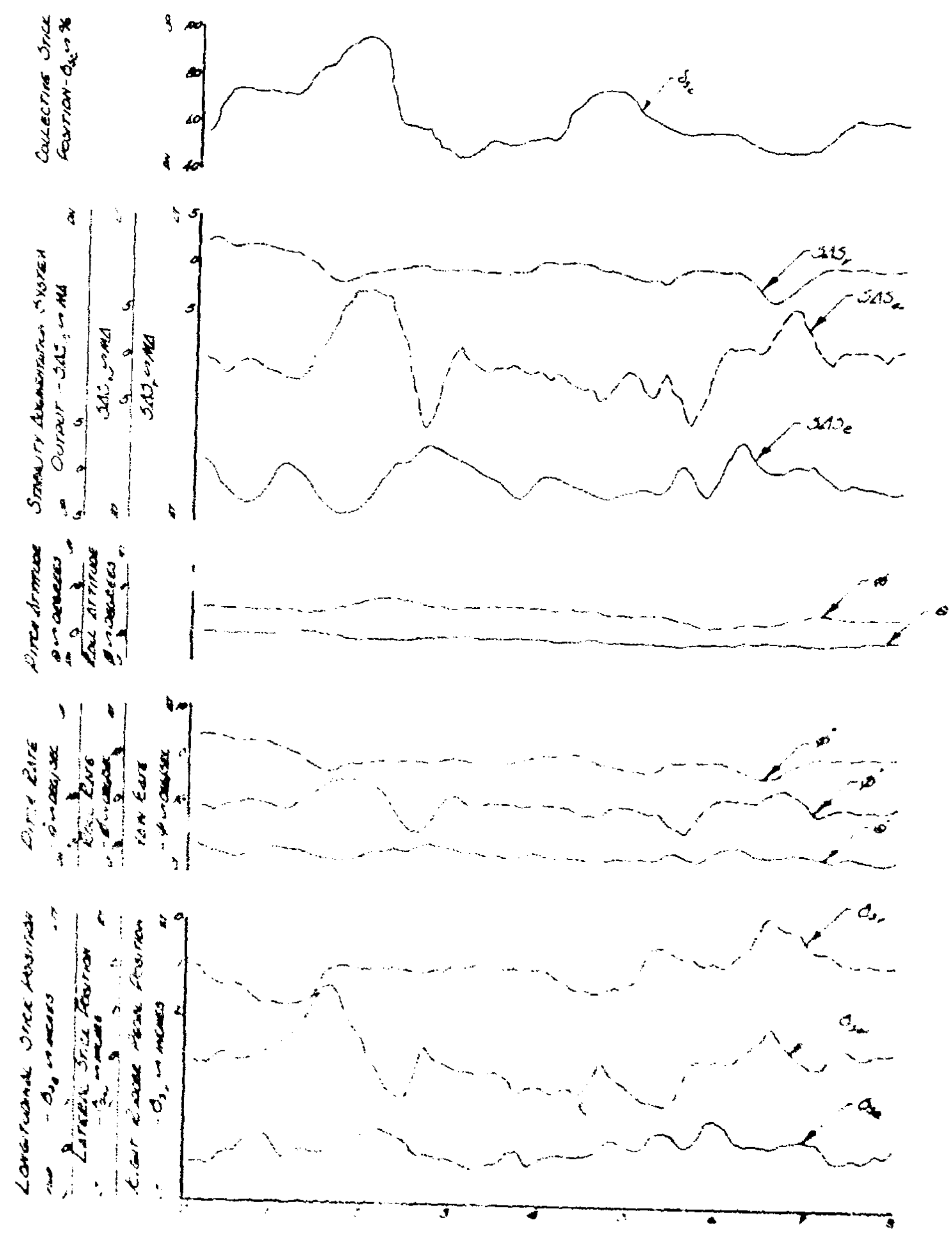


FIGURE No 126
HOVER AT A WHEEL HEIGHT OF ONE FOOT
XV-5A USA № 62-4505

FLAP POSITION = 45 DEG.
GEAR POSITION = DOWN
BETA VECTOR AVG = 8.7 DEG. FWD.
HOR. STAB. POS = 20 DEG T.E.D

AVG PRESSURE ALT = 2380 FT.
AVG G.W. = 10050 POUNDS
AVG C.G. LOC = 241.1 (MID)
SAS CONFIG = OPTIMUM.

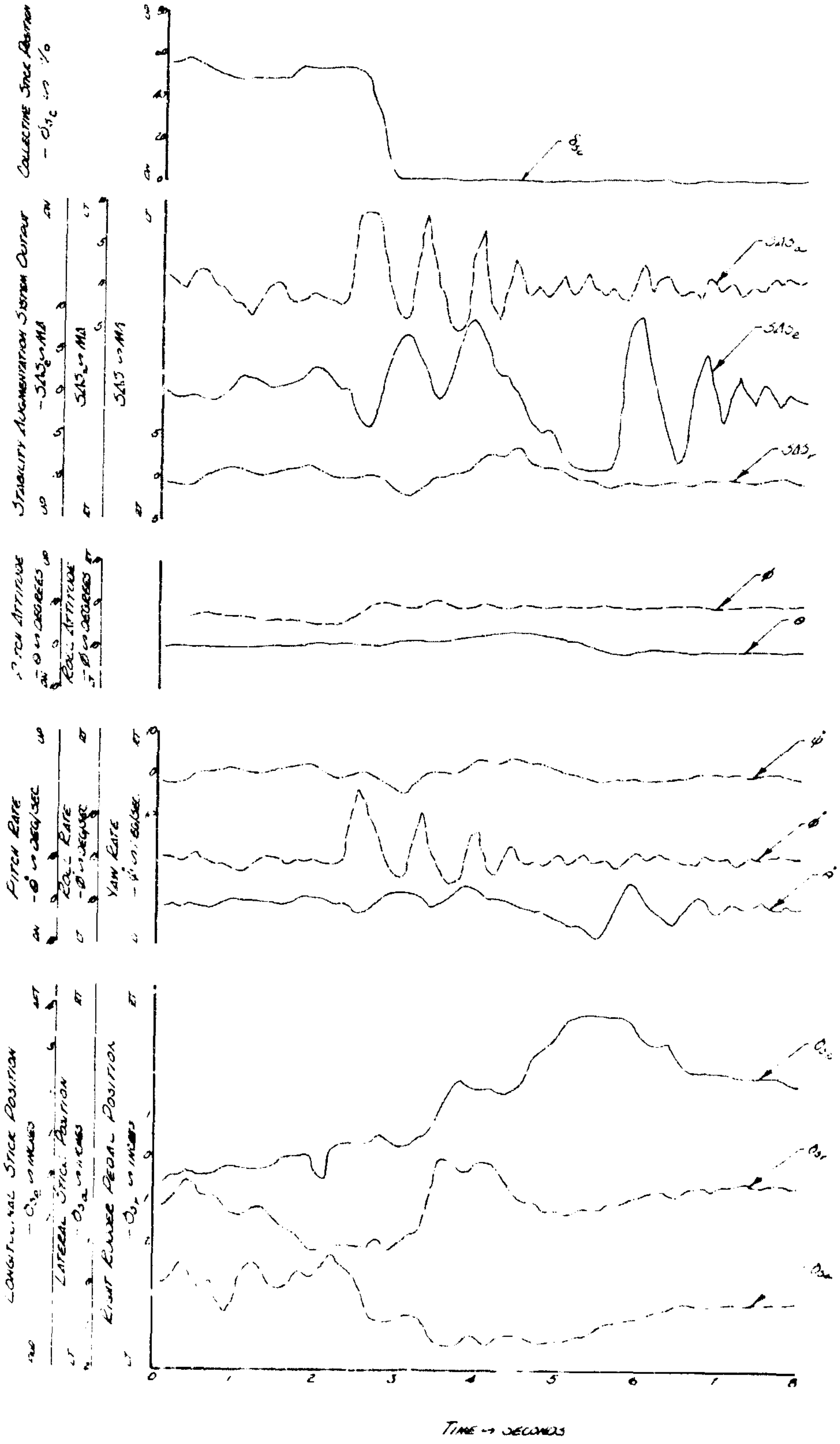


FIGURE No. 127
JET MODE TAKE-OFF AND CLIMB
XV-5A USA S/N 62-4505

FLAP POSITION = 11 DEG. AVG. C.G. LOC = 261.2 IN. (GEAR DOWN)
AVG. G.W. = 11050 LB.

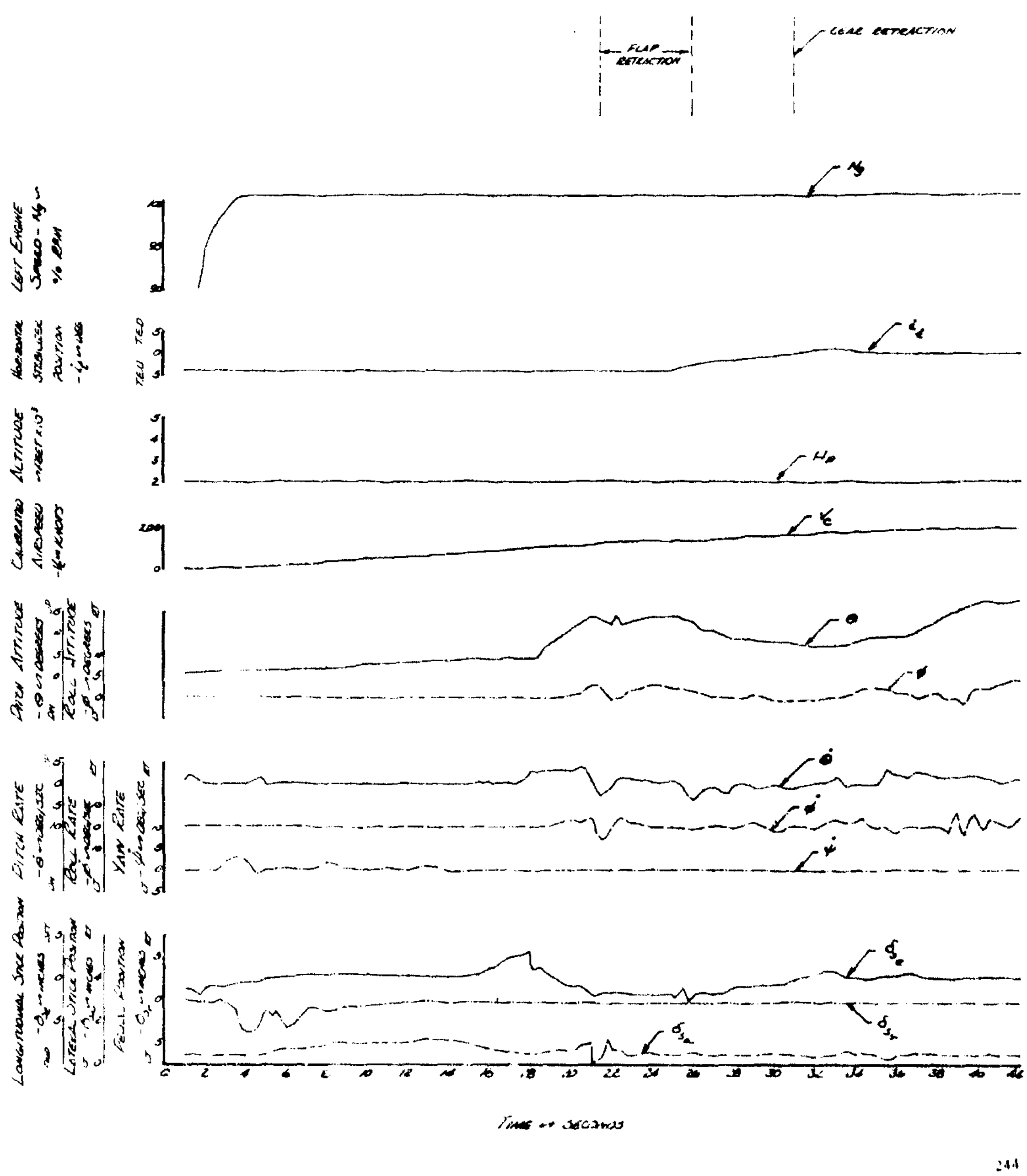
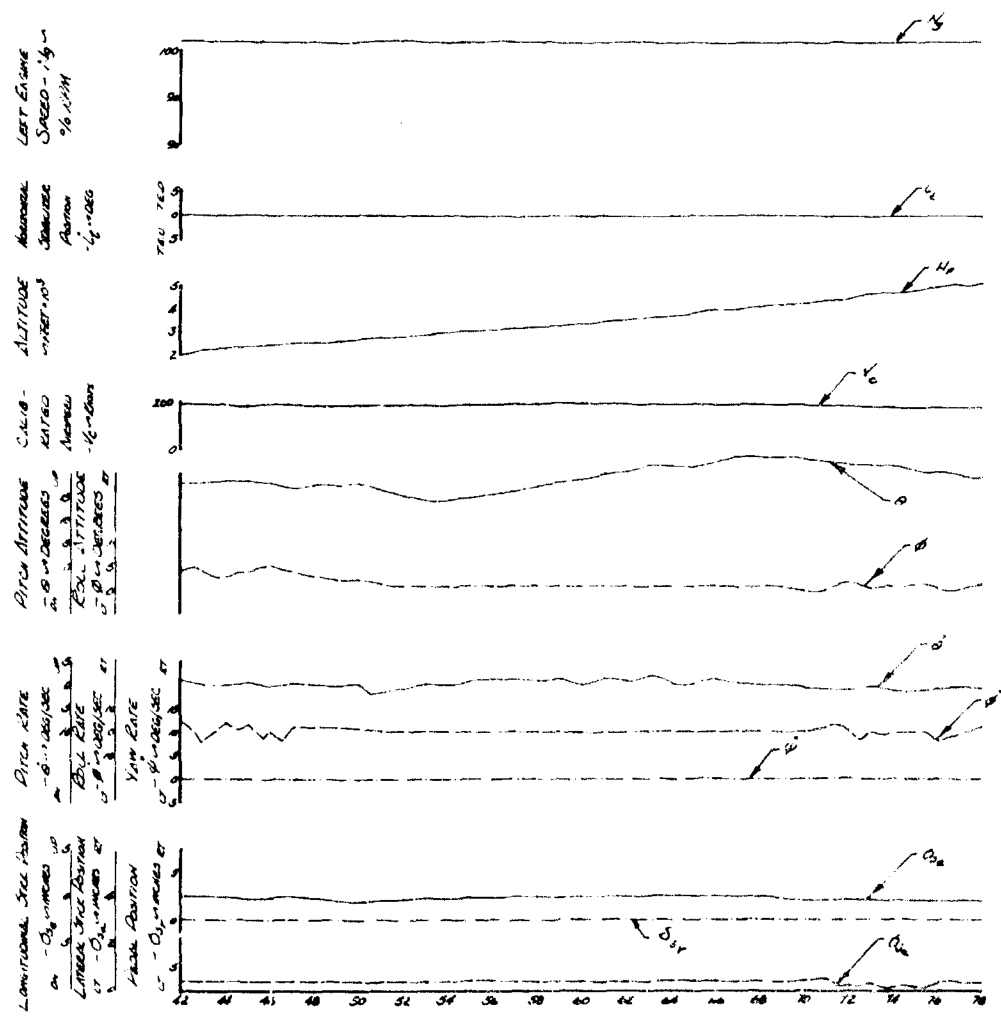


FIGURE No. 127 CONTINUED



TIME ~ SECONDS

Figure No. 128

FAN MODE TAKE-OFF

XV-5A USA S/N 62-4505

TECHNIQUE = GROUND ACCELERATION

FLAP POSITION = 45 DEG. AVG. PRESSURE ALT = 2210 FT.
GEAR POSITION = DOWN. AVG. G.W. = 10450 POUNDS
HOR. STAB POS = 20 DEG T.E.D. AVG. C.G. LOC = 240.7 IN (MAC)
SAS CONFIG = OPTIMUM

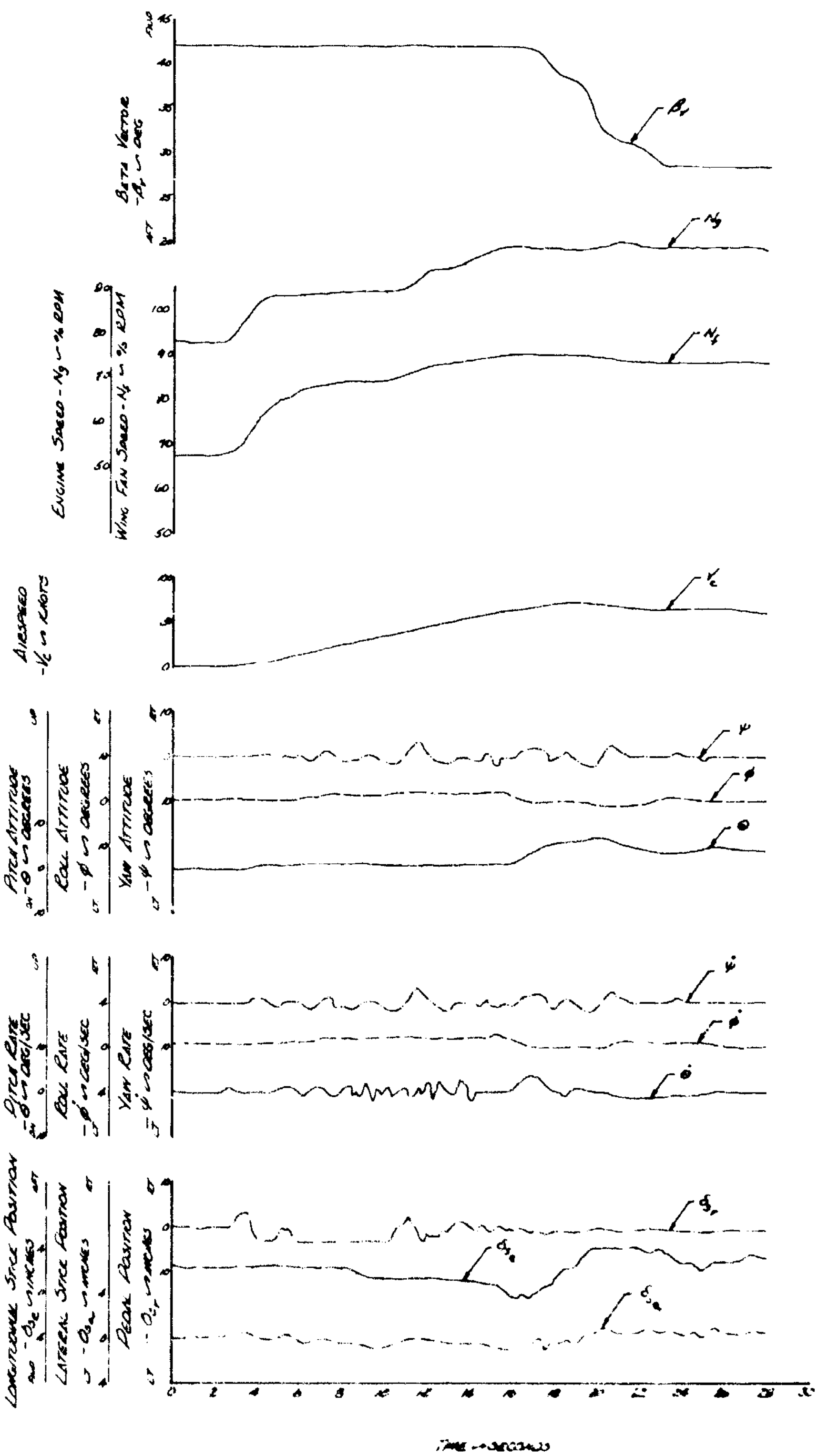


FIGURE No. 129

FAN MODE TAKE-OFF

XV-5A USA S/N 62-4505

TECHNIQUE = GROUND ACCELERATION

FLAP POSITION = 45 DEG.
GEAR POSITION = DOWN
HOR. STAB. POS = 20 DEG. T.E.U.

AVG. PRESSURE ALT = 2530 FT
AVG. G.W. = 10420 POUNDS
AVG. C.G. LOC = 240.5 IN(GEAR)

SAS CONFIG = OPTIMUM

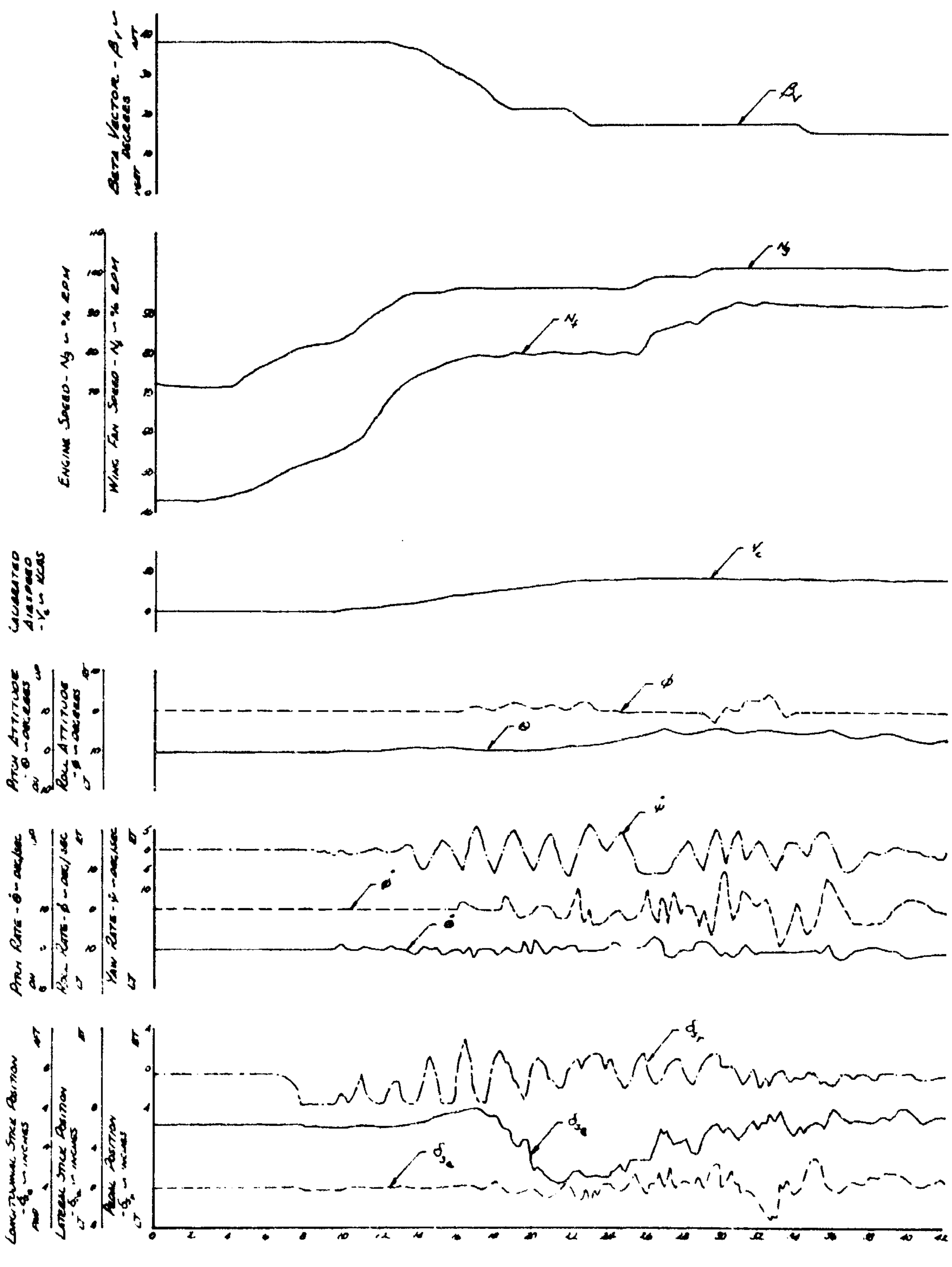
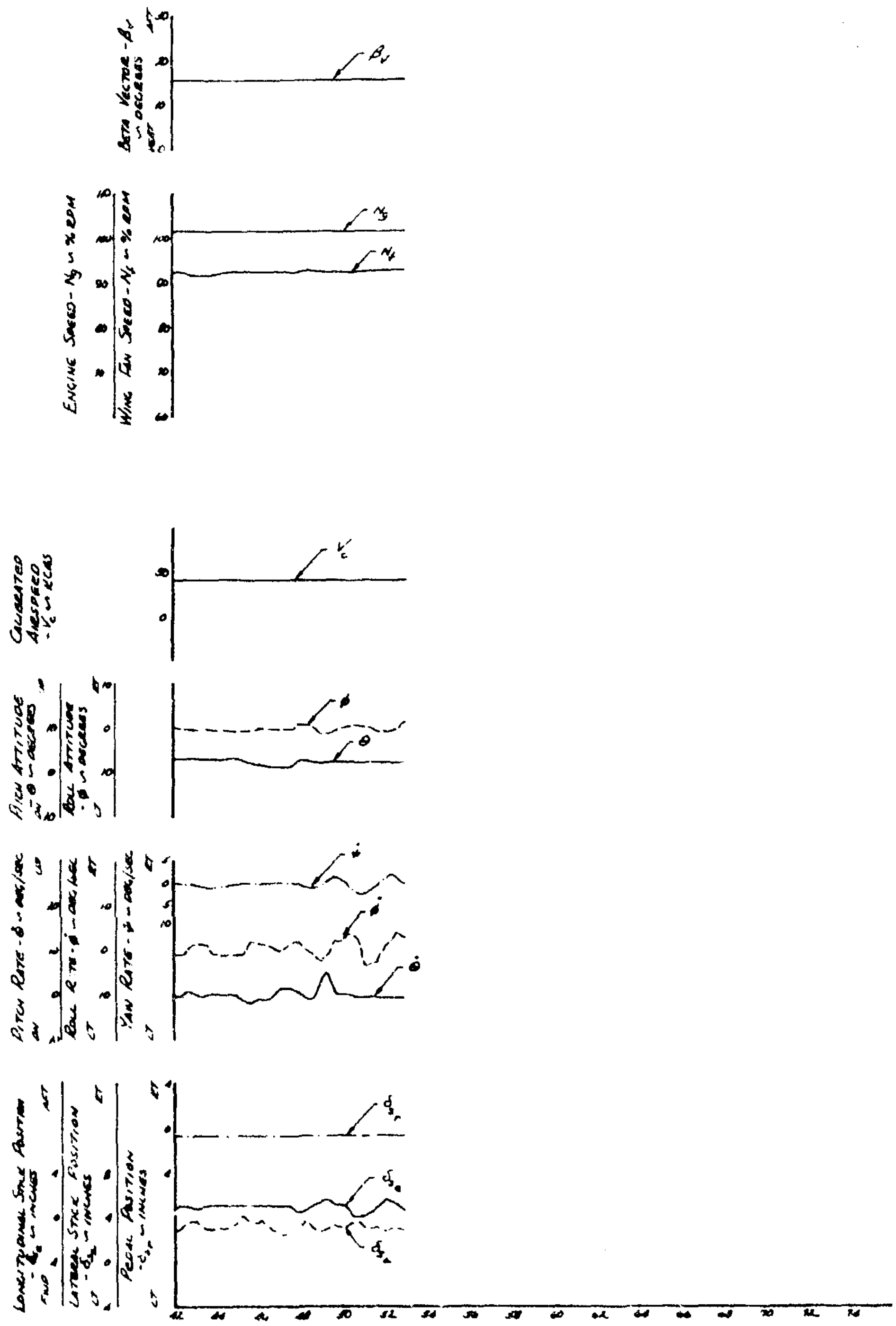


FIGURE No. 129 CONTINUED



TIME ~ SECONDS

FIGURE No. 130

FAN MODE TAKE-OFF

XV-5A USA S/N 62-4505

TECHNIQUE = LEVEL ACCEL-
ERATION FROM A 50 FOOT HOVER

FLAP POSITION = 45 DEG
HOR. STAB. POS = 20 DEG. T.E.D.
AVG. PRESSURE ALT = 2250 FT.

AVG. G.W = 10260 FT
AVG. C.G. LOC = 240.3 IN(MAC)
SAS CONFIG = OPTIMUM

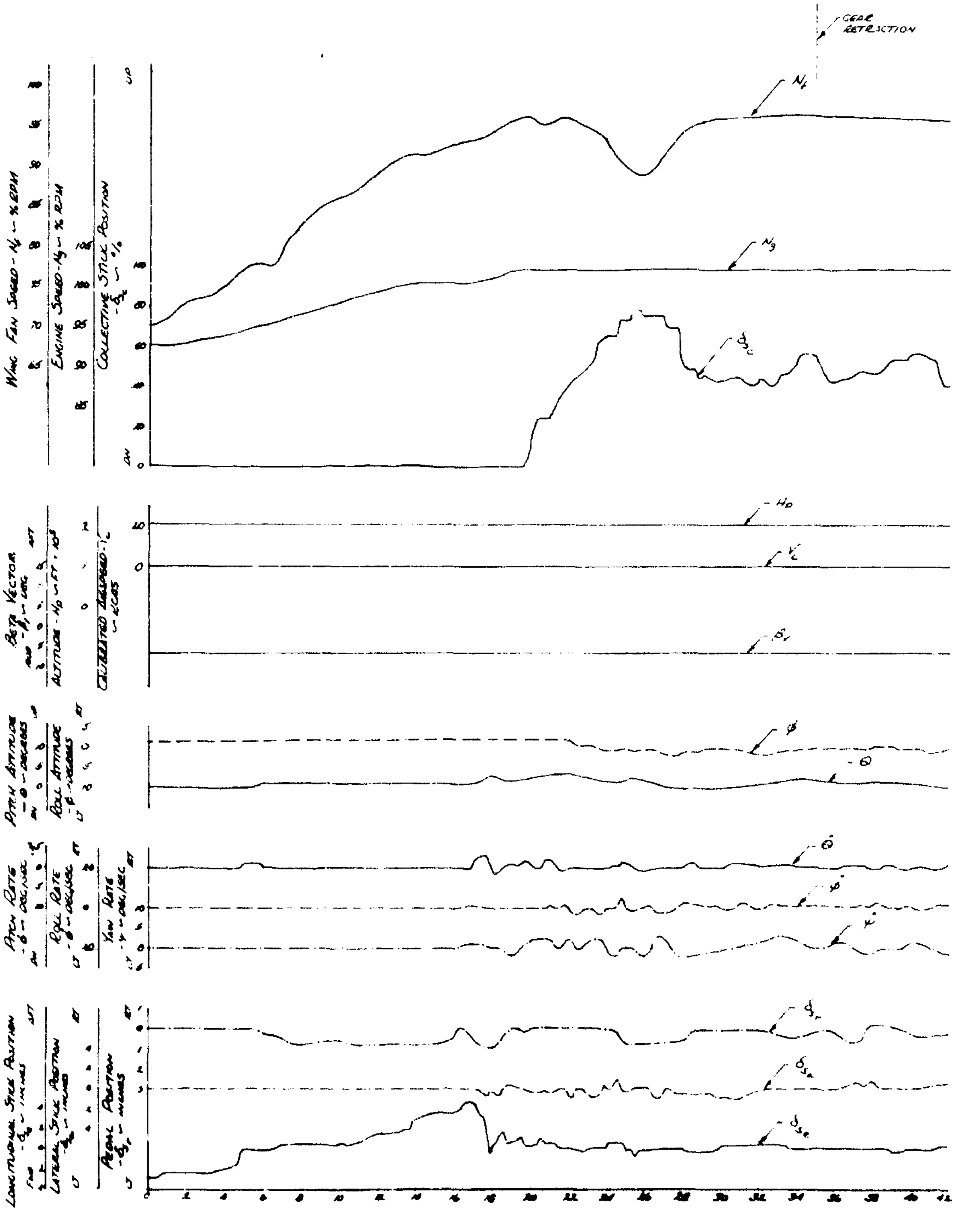


FIGURE No. 130 CONTINUED

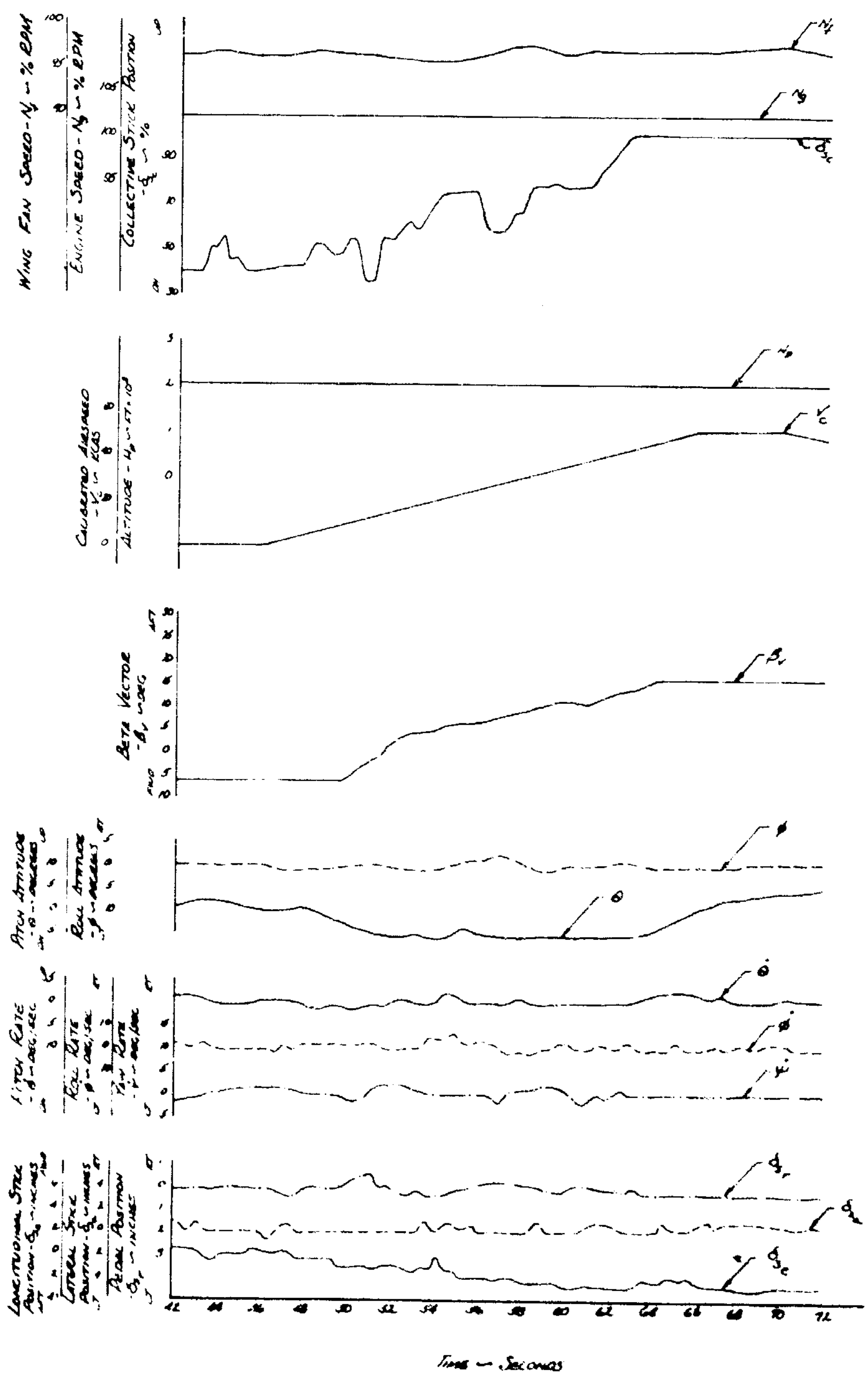
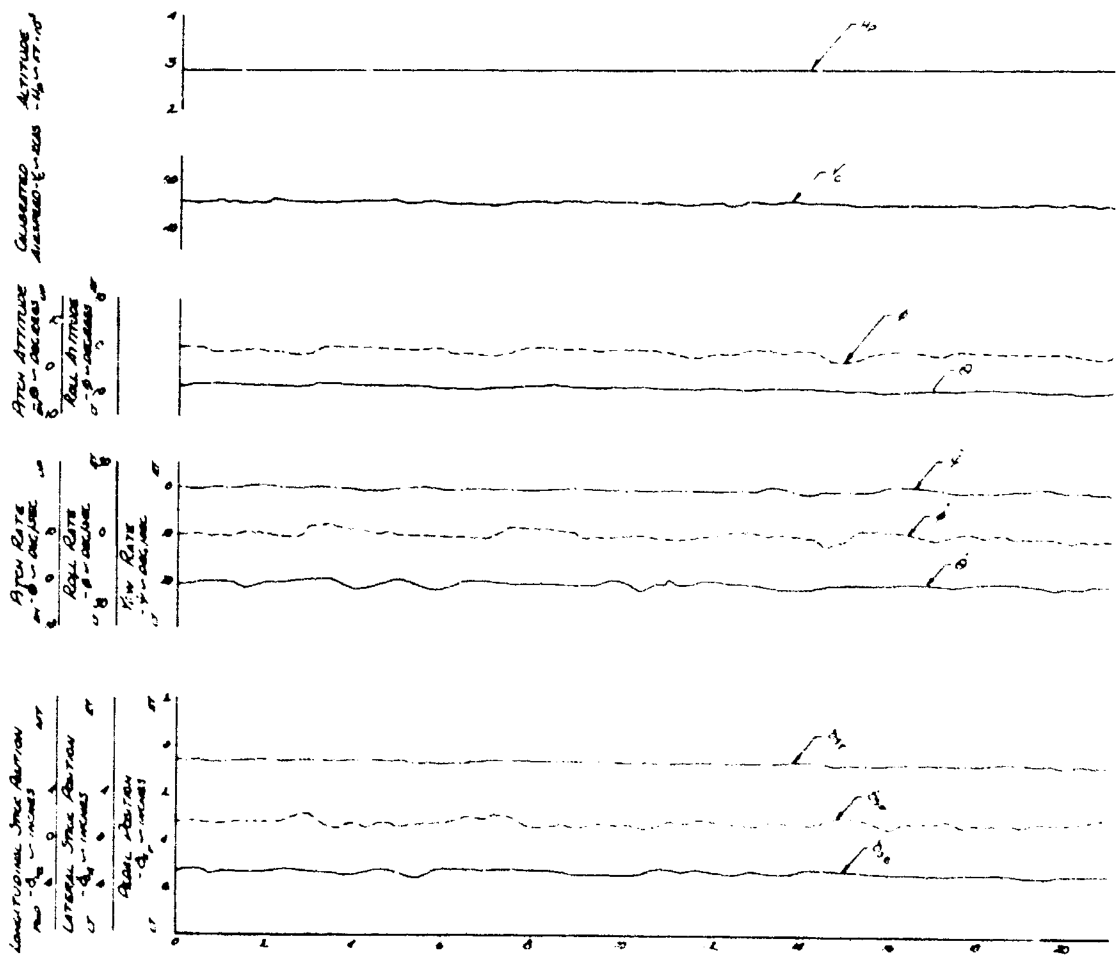


FIGURE No. 131
FAN MODE CLIMB
XV-5A USA S/N 62-4305

FLAP POSITION = 45 DEG	BETA VECTOR ANG. = 15.5 DEG. AFT.
GEAR POSITION = UP	AVG. G.W. = 10140 POUNDS.
COLL. STICK POS = 100% (UP)	AVG. C.G. LOC = 240.5 IN. (MID)
HOR. STAB. POS = 20 DEG. T.E.D.	SAS CONFIG = OPTIMUM.



TIME ~ SECONDS

FIGURE No. 132

TRANSITION STABILITY AND CONTROL CHARACTERISTICS

XV-5A USA S/N 62-4505

TECHNIQUE = FAN MODE VERTICAL TAKE-OFF, LEVEL ACCELERATION AND CONVERSION, JET MODE CLIMB AND ACCELERATION.

AVG. G.W = 11080 LB
AVG. C.G. LOC = 241.2 IN (MHR)
SAS CONFIG = OPTIMUM

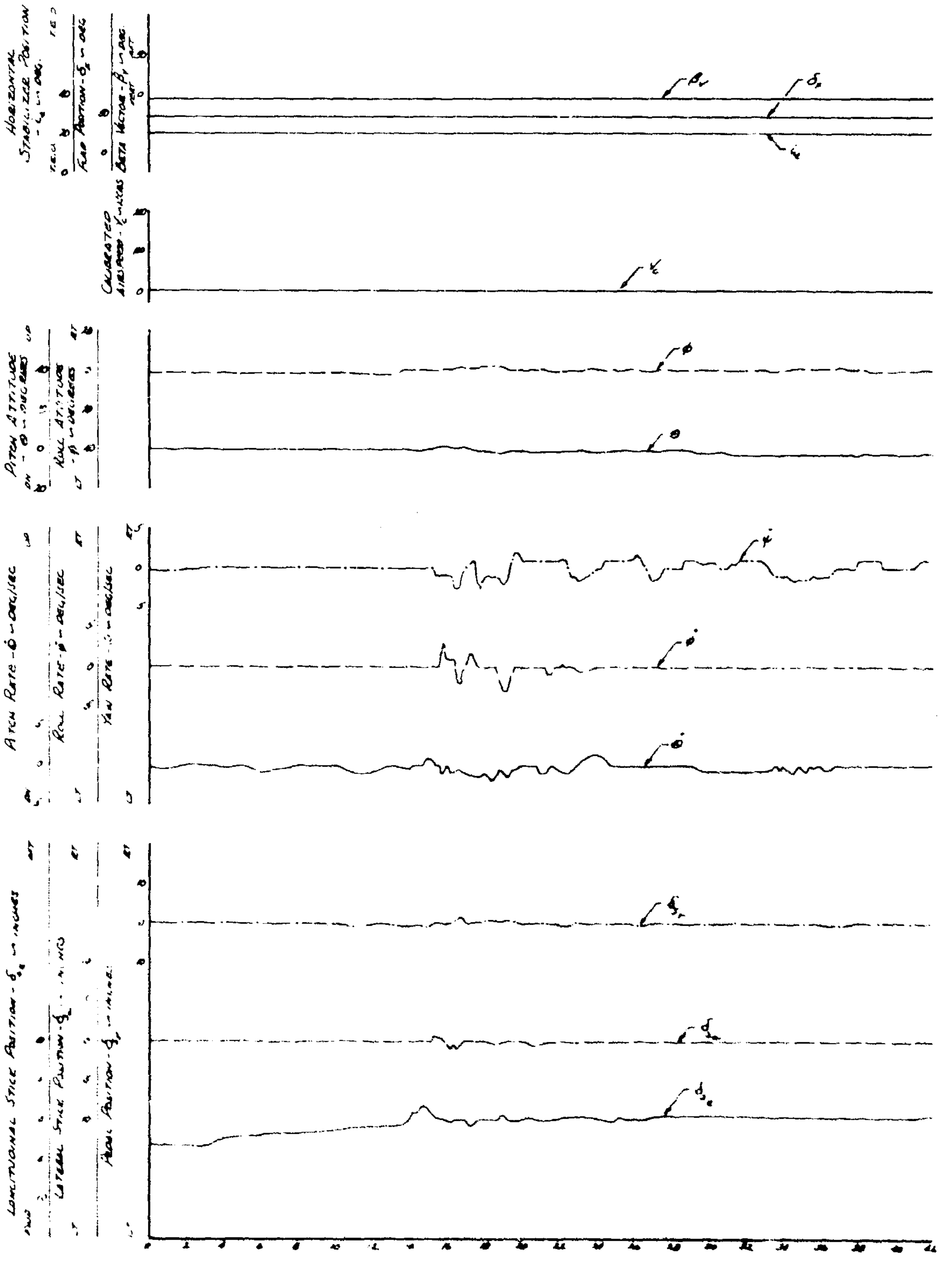


FIGURE No. 132 CONTINUED

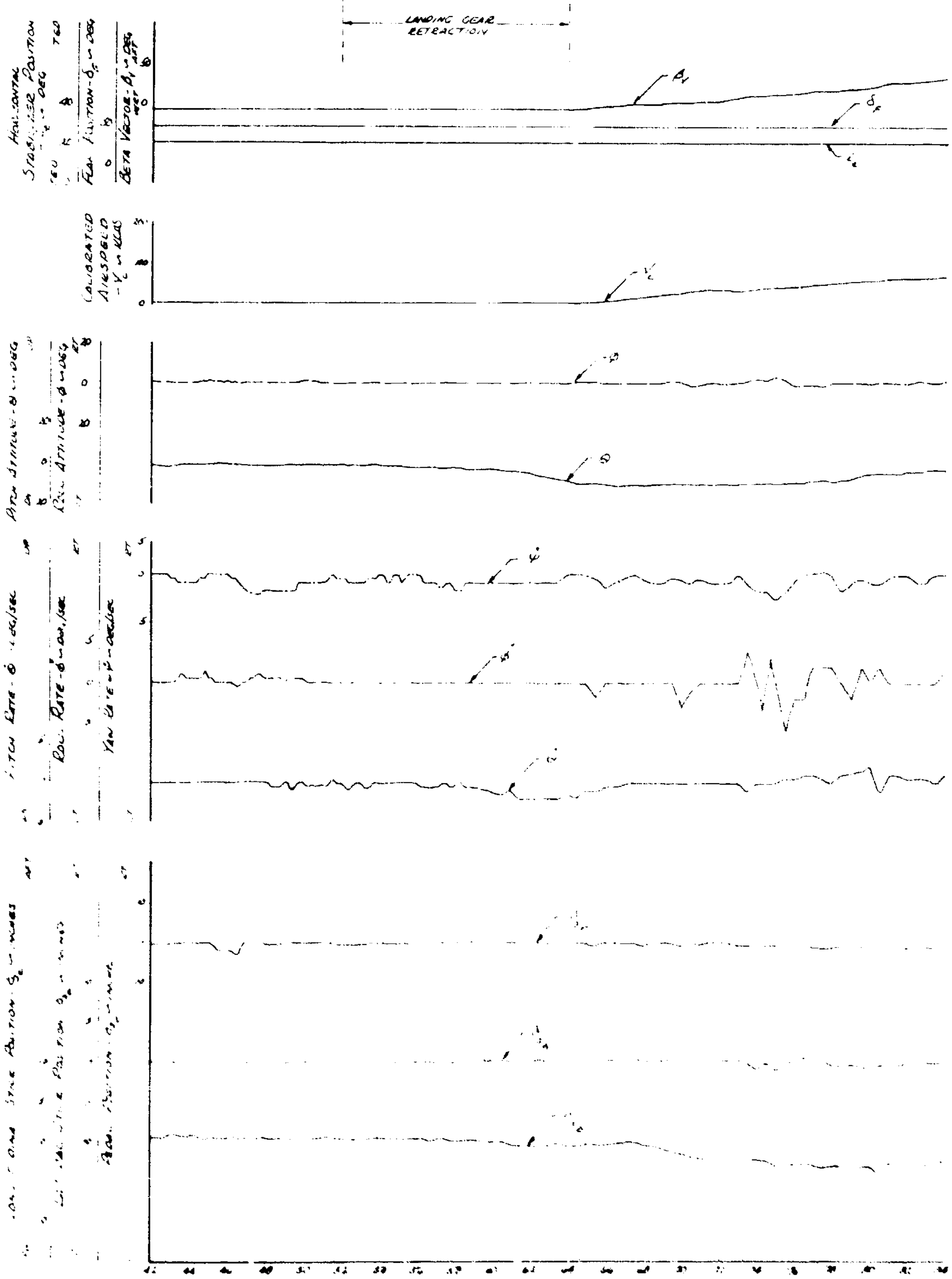


FIGURE NO. 132 CONTINUED

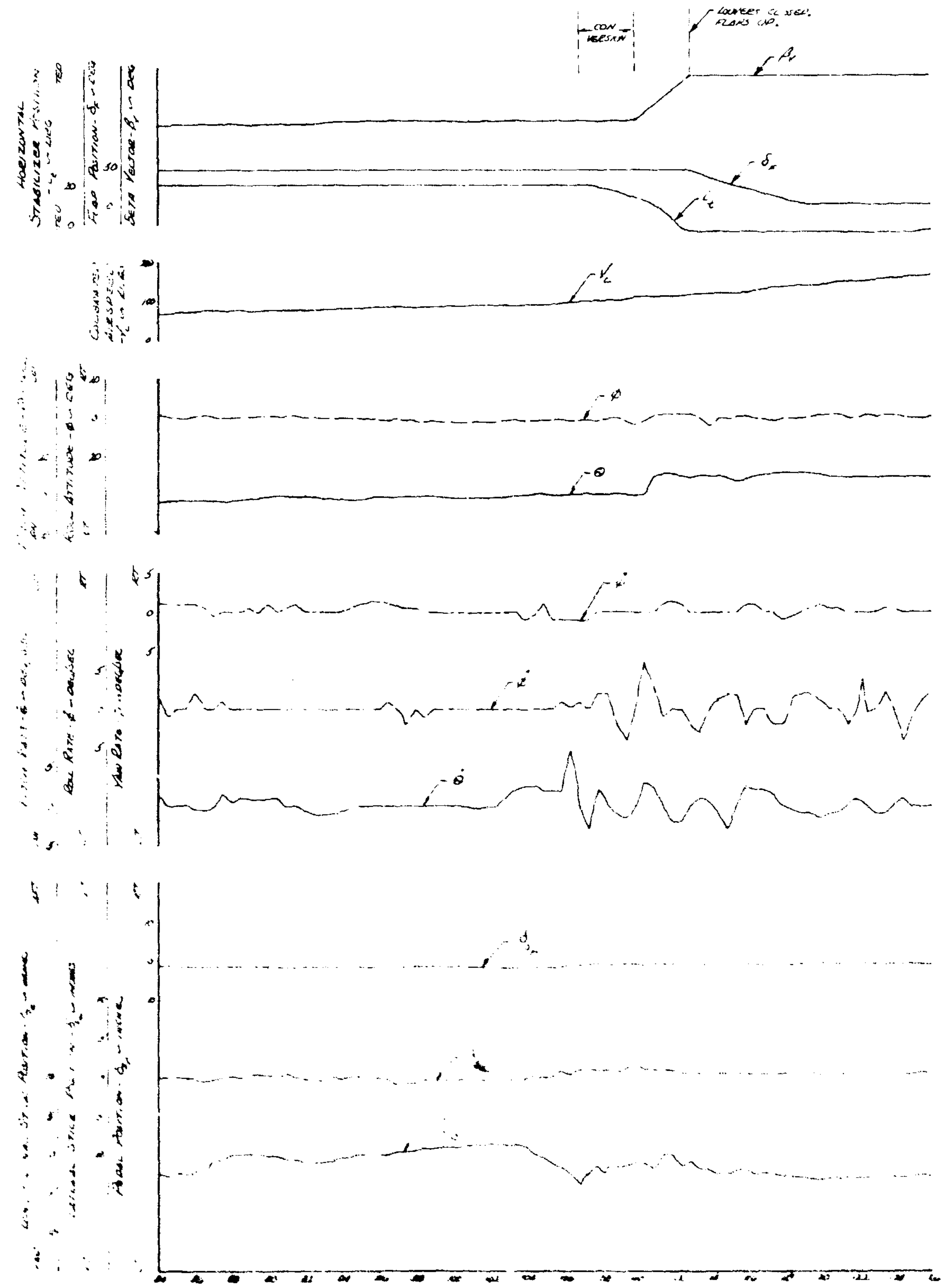


FIGURE No. 132 CONTINUED.

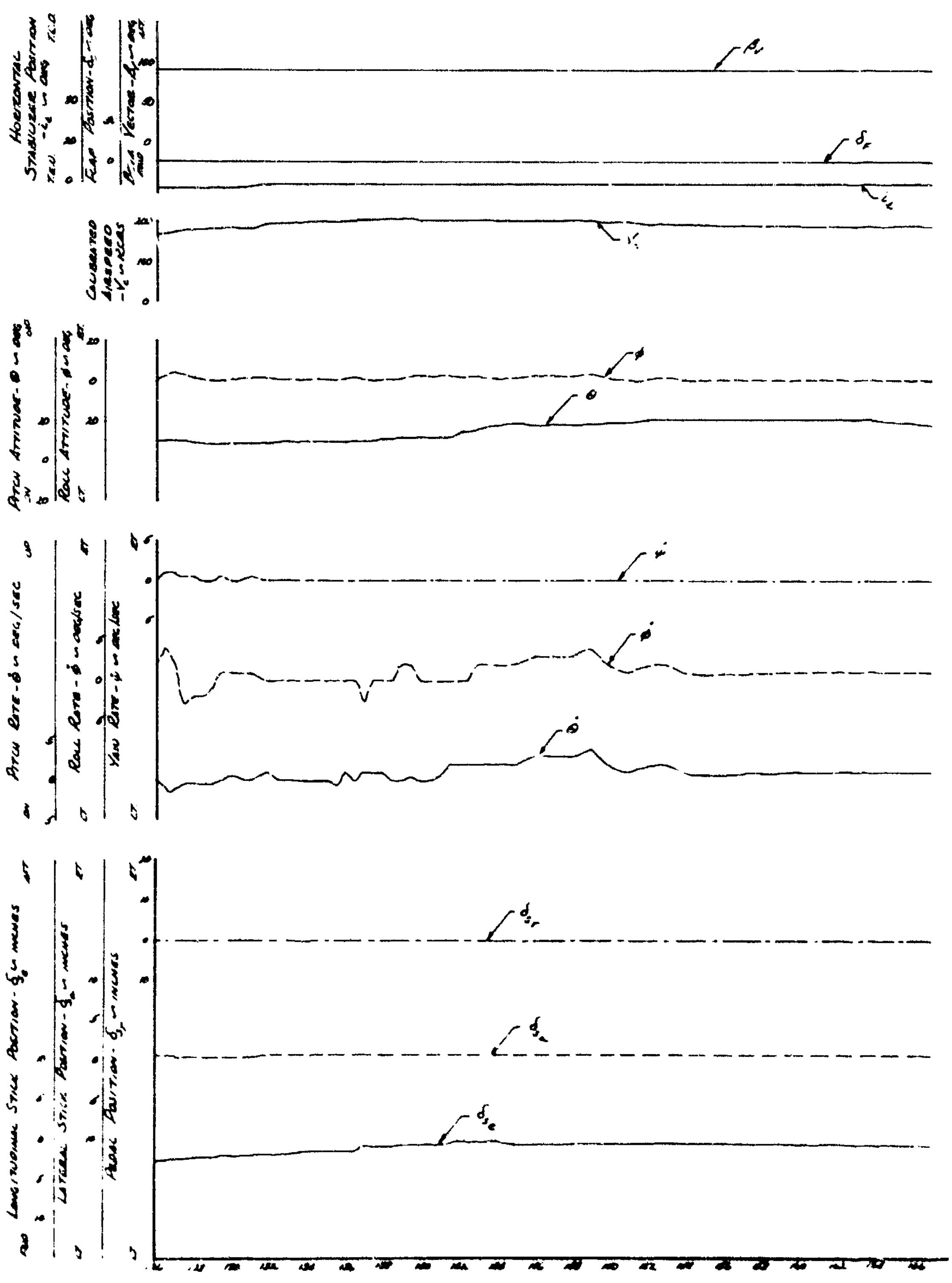


FIGURE No. 133

ALTITUDE CONVERSION

JET MODE TO FAN MODE

XV-5A USA S/N 62-4505

FLAP POSITION = 45 DEG
GEAR POSITION = UP
COLL. STICK POS = 100% (UP)
A/C. PRESSURE ALT = 3080 FT.

A/C. G.W. = 9740 LB
A/C. C.G. LOC. = 210.5 in(N.M.)
SAS CONFIG = OPTIMUM
HOR. STAB. POS = 3 DEG.
T.E.U. (AT CONVERSION)

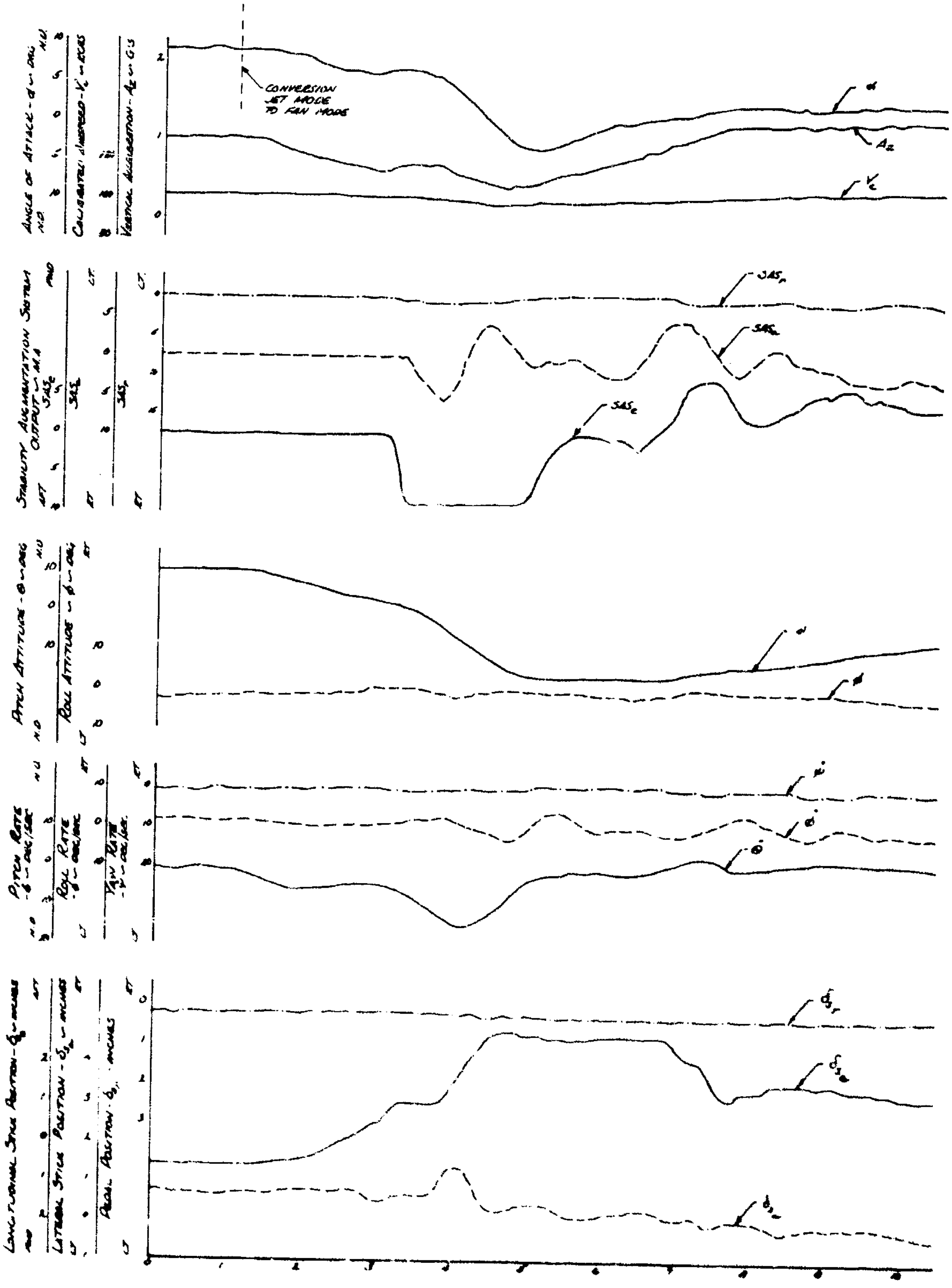


FIGURE No. 134

ALTITUDE CONVERSION

JET MODE TO FAN MODE

XV-5A USA S/N 62-4505

FLAP POSITION = 45 DEG.
GEAR POSITION = UP
COLL. STICK POS = 100% (UP)
AVG. PRESSURE ALT = 5180 FT.

AVG. G.W. = 10070 LB
AVG. C.G. LOC = 240.3 IN. NOM.
SAS CONFIG = OPTIMUM
HOR. STAB. POS = 3 DEG.
T.E. U (AT CONVERSION)

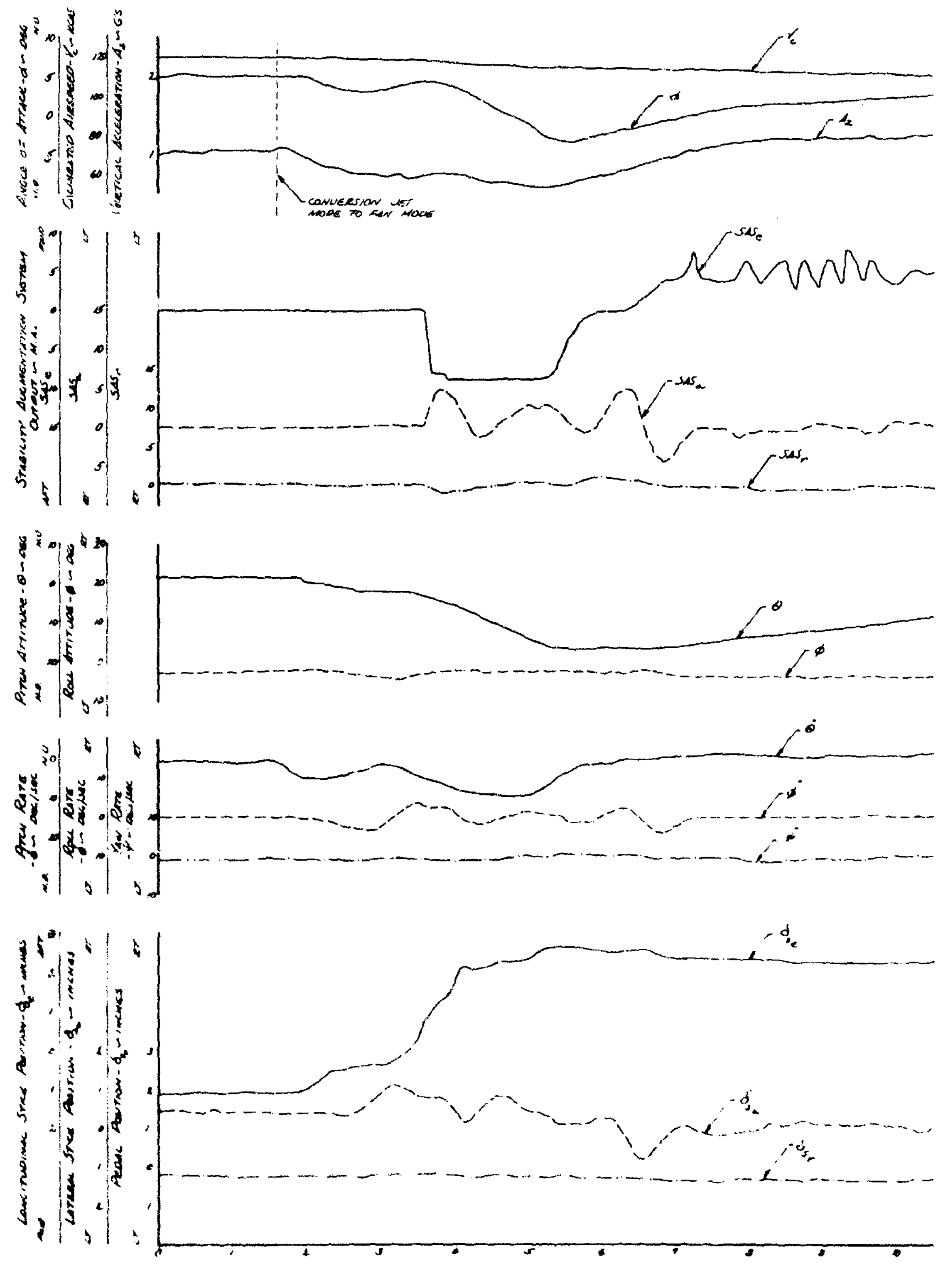


FIGURE No. 135

FAN MODE TO JET MODE CONVERSION

XV-5A USA S/N 62-4505

FLAP POSITION = 45 DEG.
GEAR POSITION = UP
COLL. STICK POS = 100% (UP)
AVG. PRESSURE ALT = 2830 FT.

AVG. G.W = 11050 LB.
AVG. C.G. LOC = 241.2 IN(MID)
SAS CONFIG = OPTIMUM
HOR. STAB POS = 20 DEG
T.E.D. (AT CONVERSION)

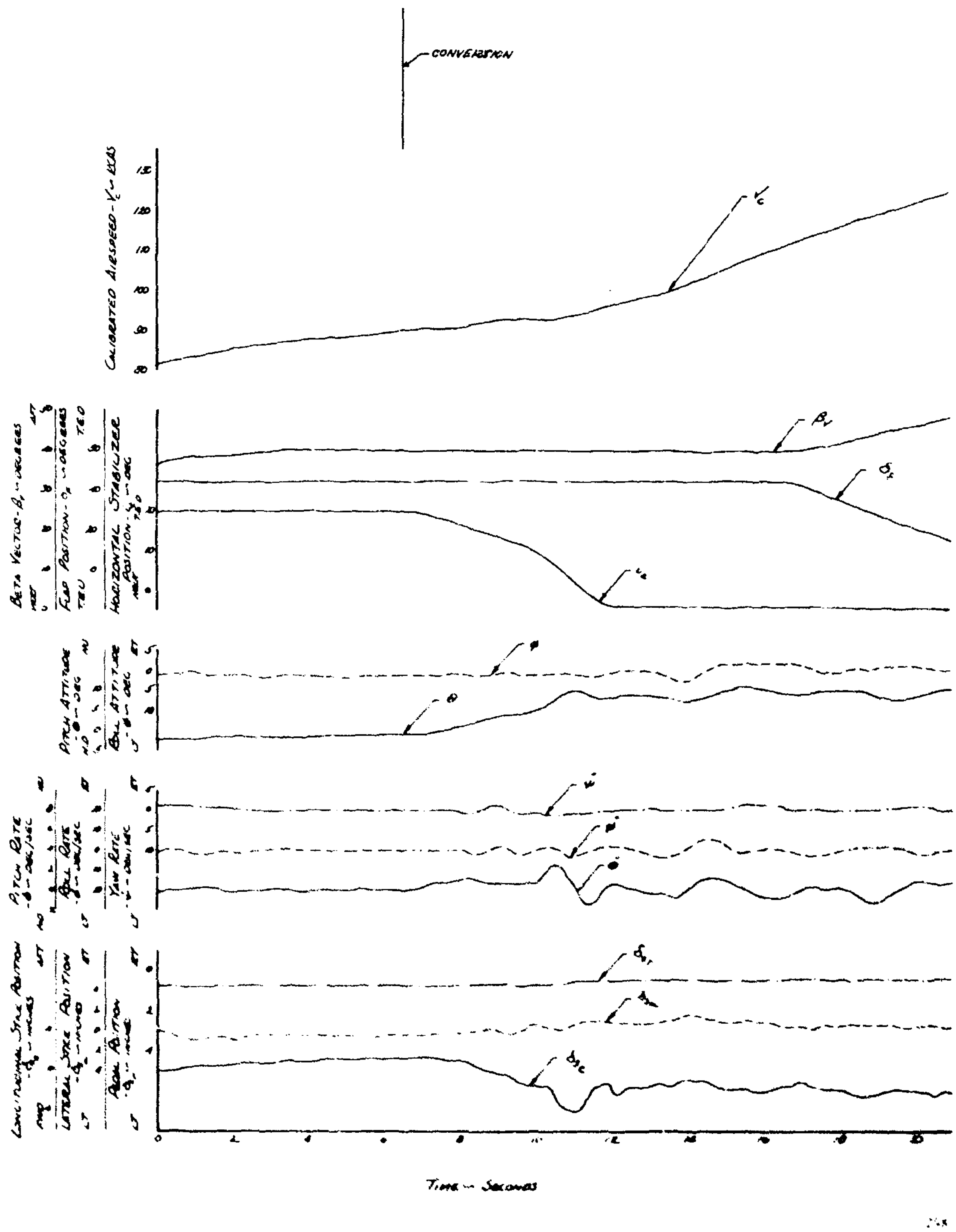


FIGURE No. 136
FAN MODE TRANSLATION WITH
STABILITY AUGMENTATION SYSTEM OFF
XV-5A USA S/N 62-4505

FLAP POSITION = 45 DEG.
GEAR POSITION = DOWN
HOR. STAB. POS = 20 DEG. T.E.D

AVG. PRESSURE ALT = 2330 FT
AVG. G.W = 10460 POUNDS
AVG. C.G. LOC = 280.0 IN (MID)

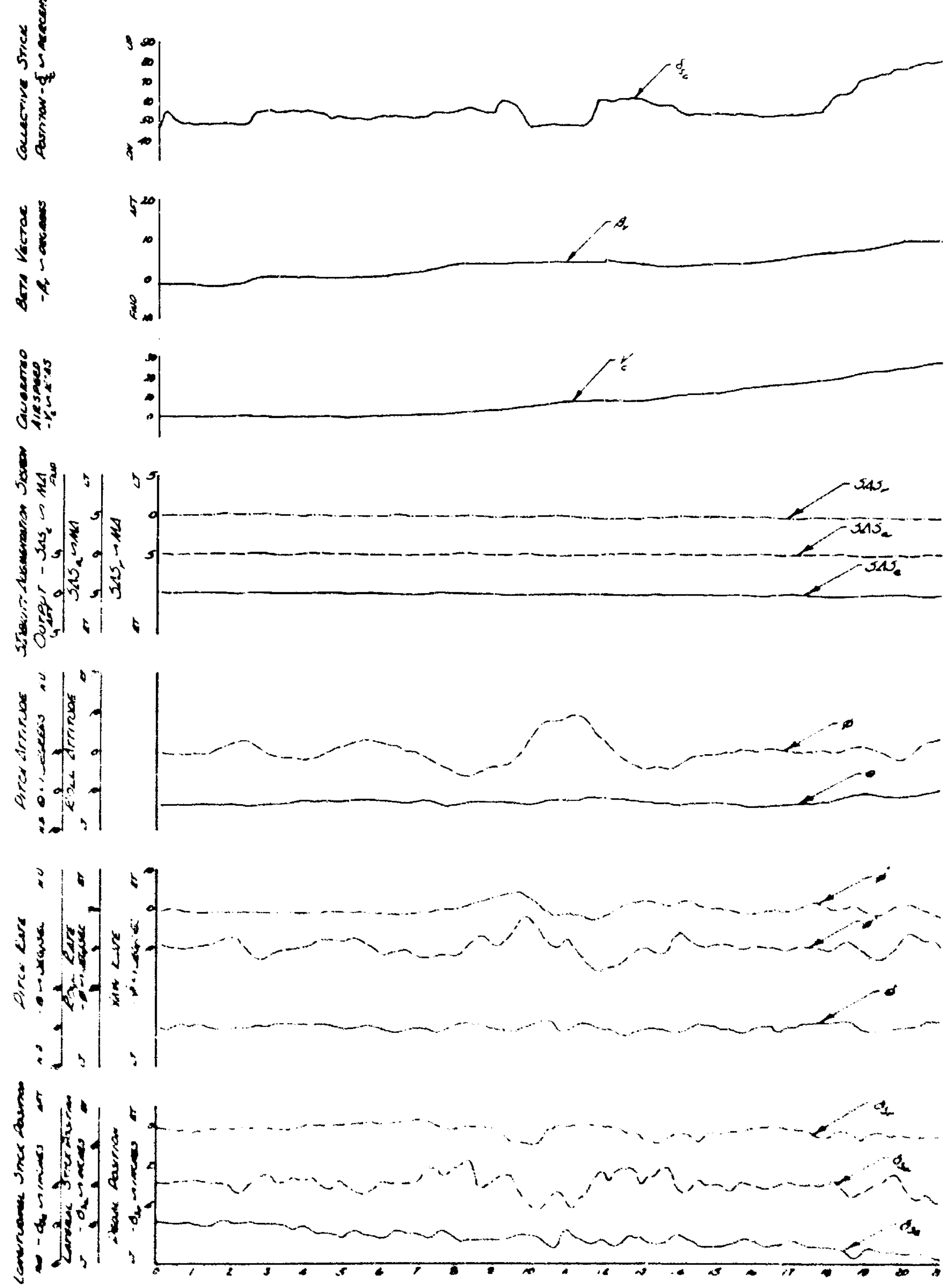
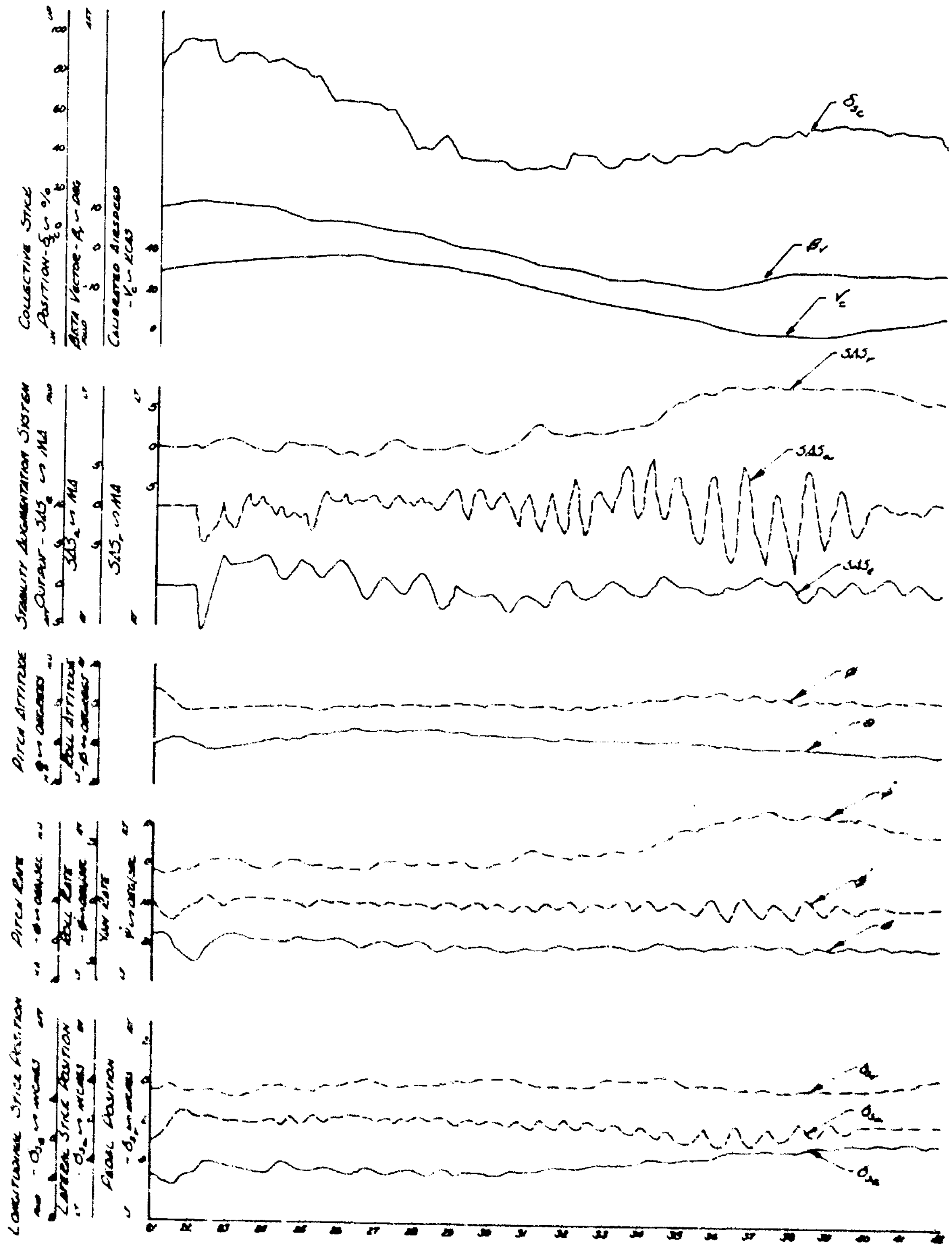


FIGURE No. 136 CONTINUED



TIME ~ SECONDS

FIGURE No. 137
FLIGHT CHARACTERISTICS OF BASIC AIRCRAFT
DURING CONVERSION AND FAN MODE FLIGHT
XV-5A USA S/N 62-4505

SAS OFF

FLAP POSITION = 45 DEG
GEAR POSITION = UP
AVG. C.W. = 9850 LB
AVG. C.G. LOC = 240.8 IN (AMB)
COLL. STICK POS = 100% (UP)

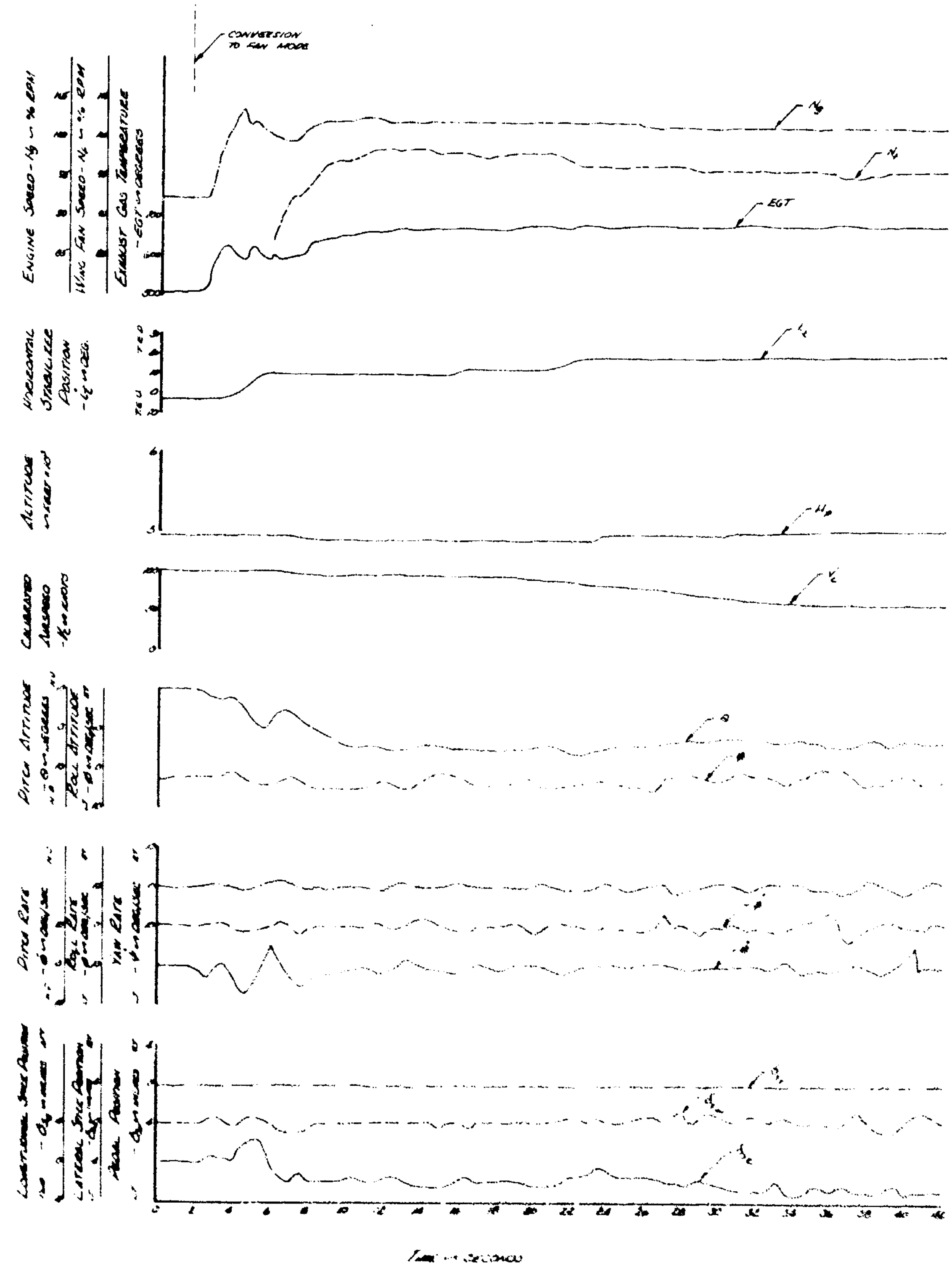


FIGURE No. 137 CONTINUED

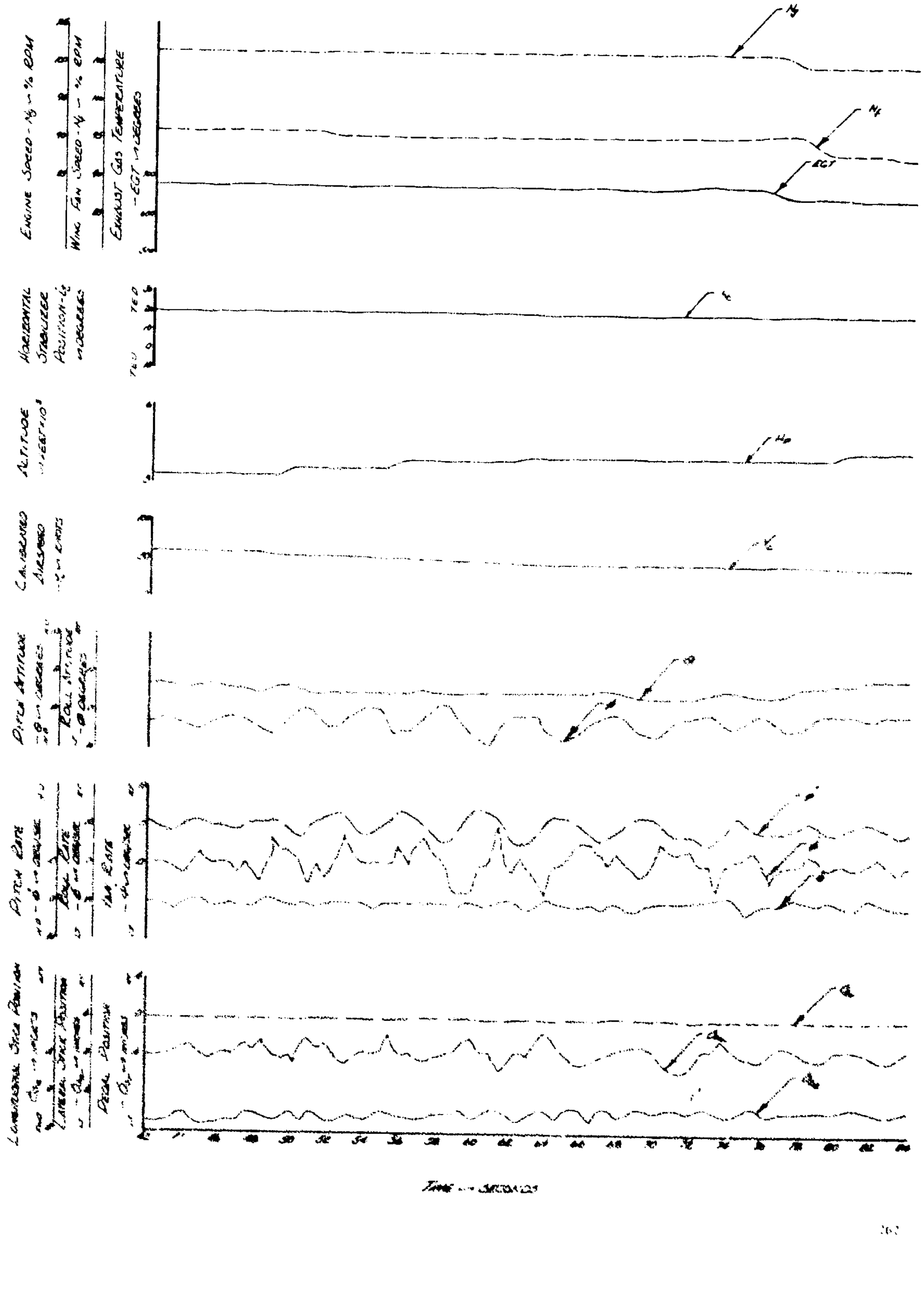
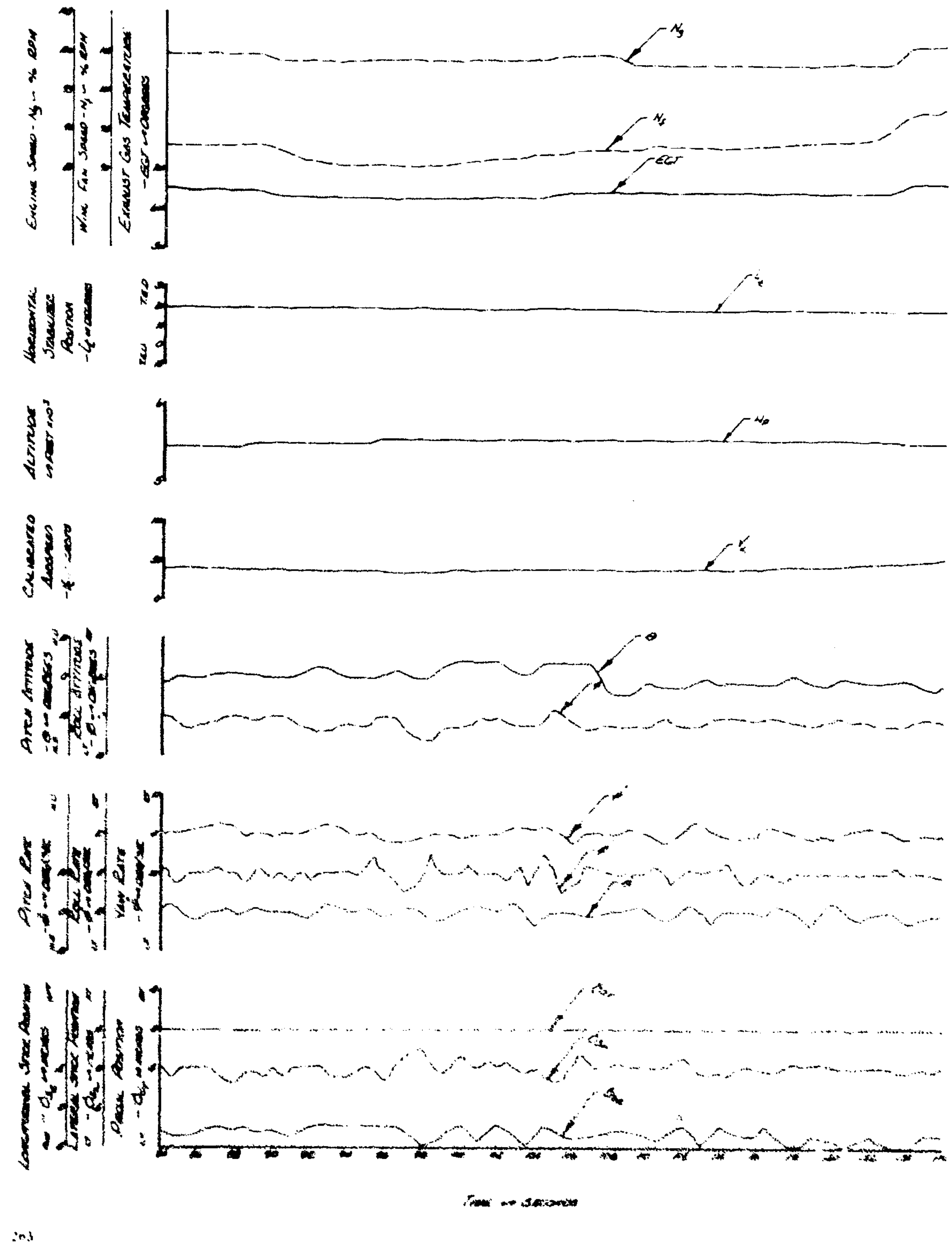


Figure No. 137 continued



Time ~ Seconds

FIGURE No. 131 CONTINUED

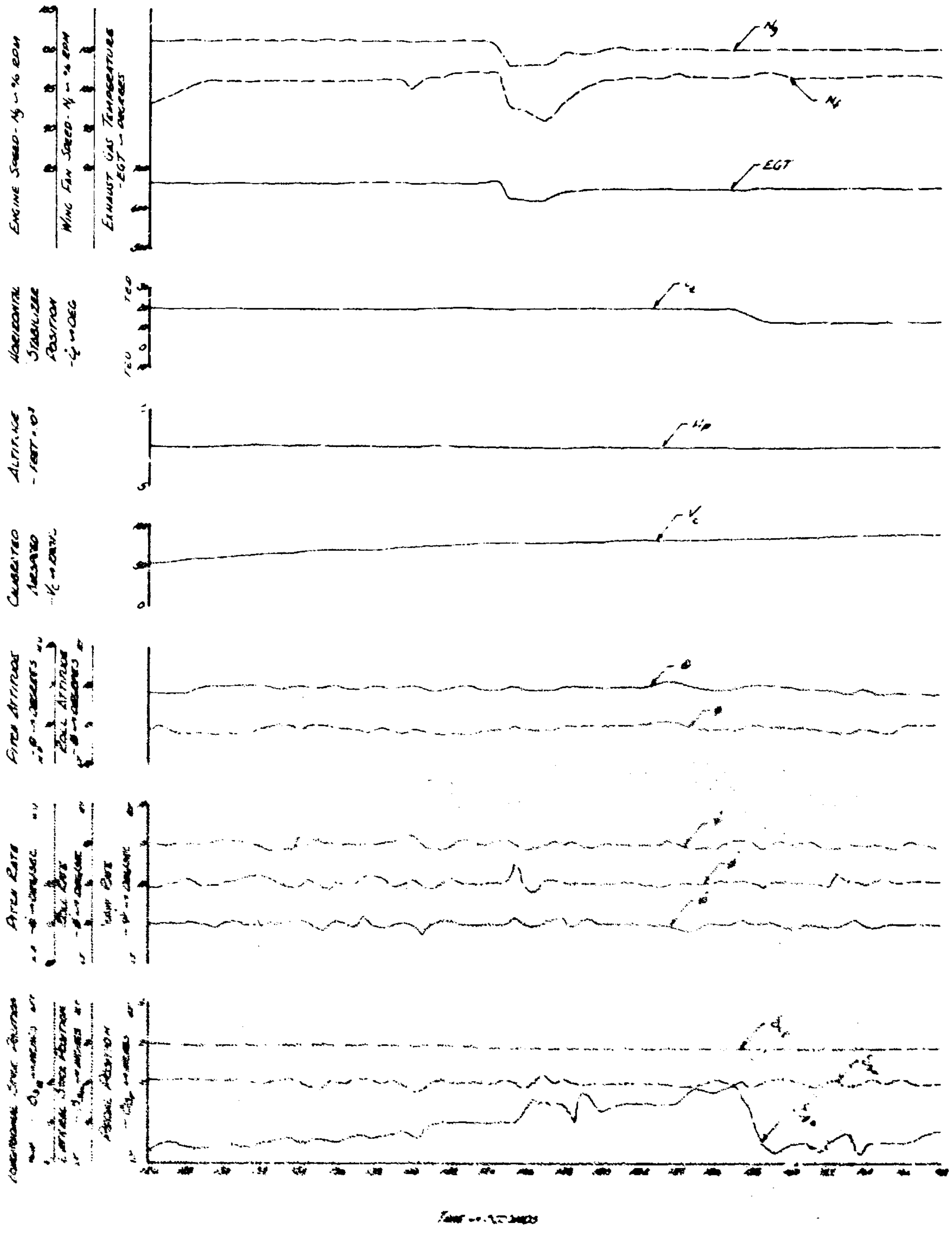


FIGURE No. 137 CONTINUED

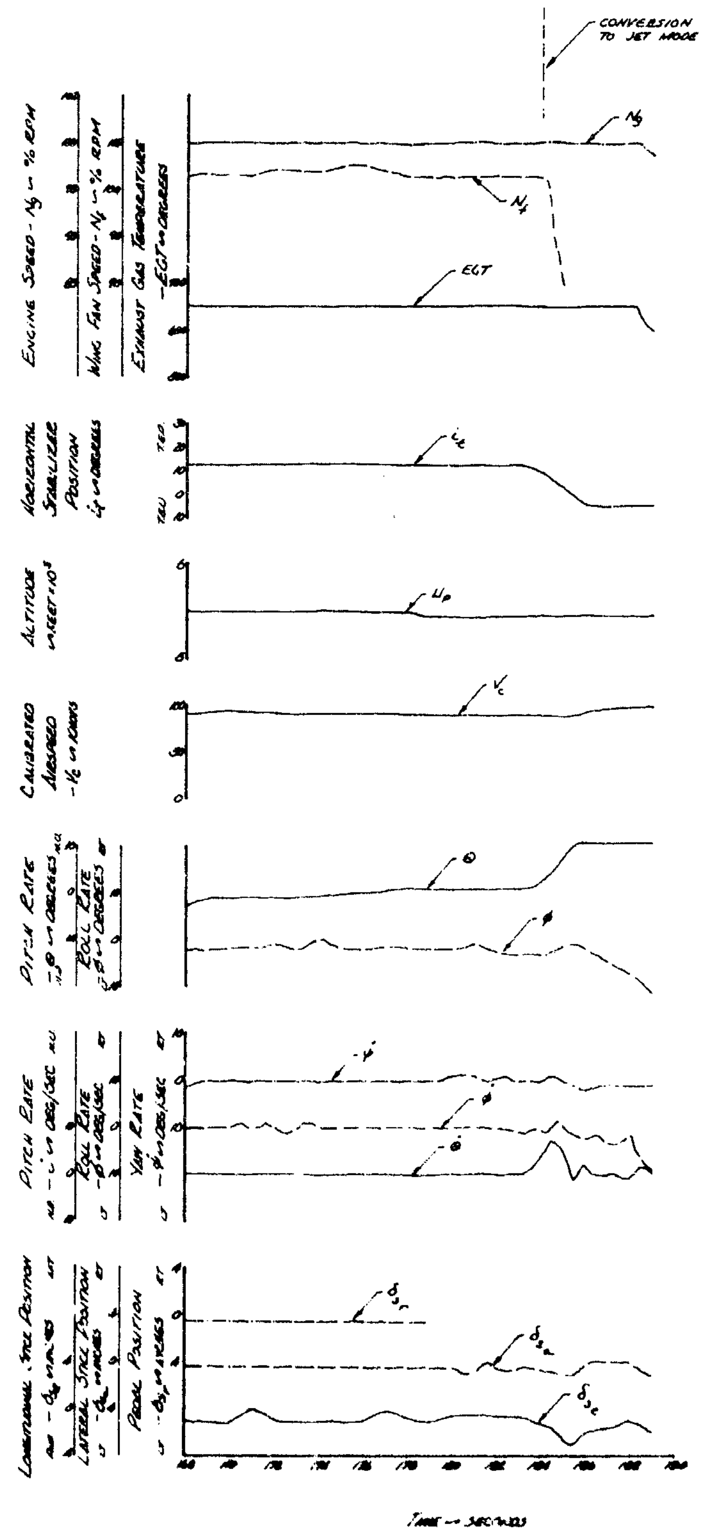


FIGURE No. 138
SUMMARY OF STATIC LONGITUDINAL STABILITY DURING TRANSITION

CONFIGURATION	GROSS WT. ~LB	PRESSURE ALT ~ FT	C.G. LOC ~IN.	GEAR POS	FLAP POS. ~DEG
FAN MODE	10000	3500	241.0 (MID)	DOWN	45
JET MODE (P.C.)	104[illegible]	5000	241.5 (MID)	UP & DOWN	45
JET MODE (CR.)	9900	10000	241.5 (MID)	UP	0

CURVES DERIVED FROM FIGURE NO.

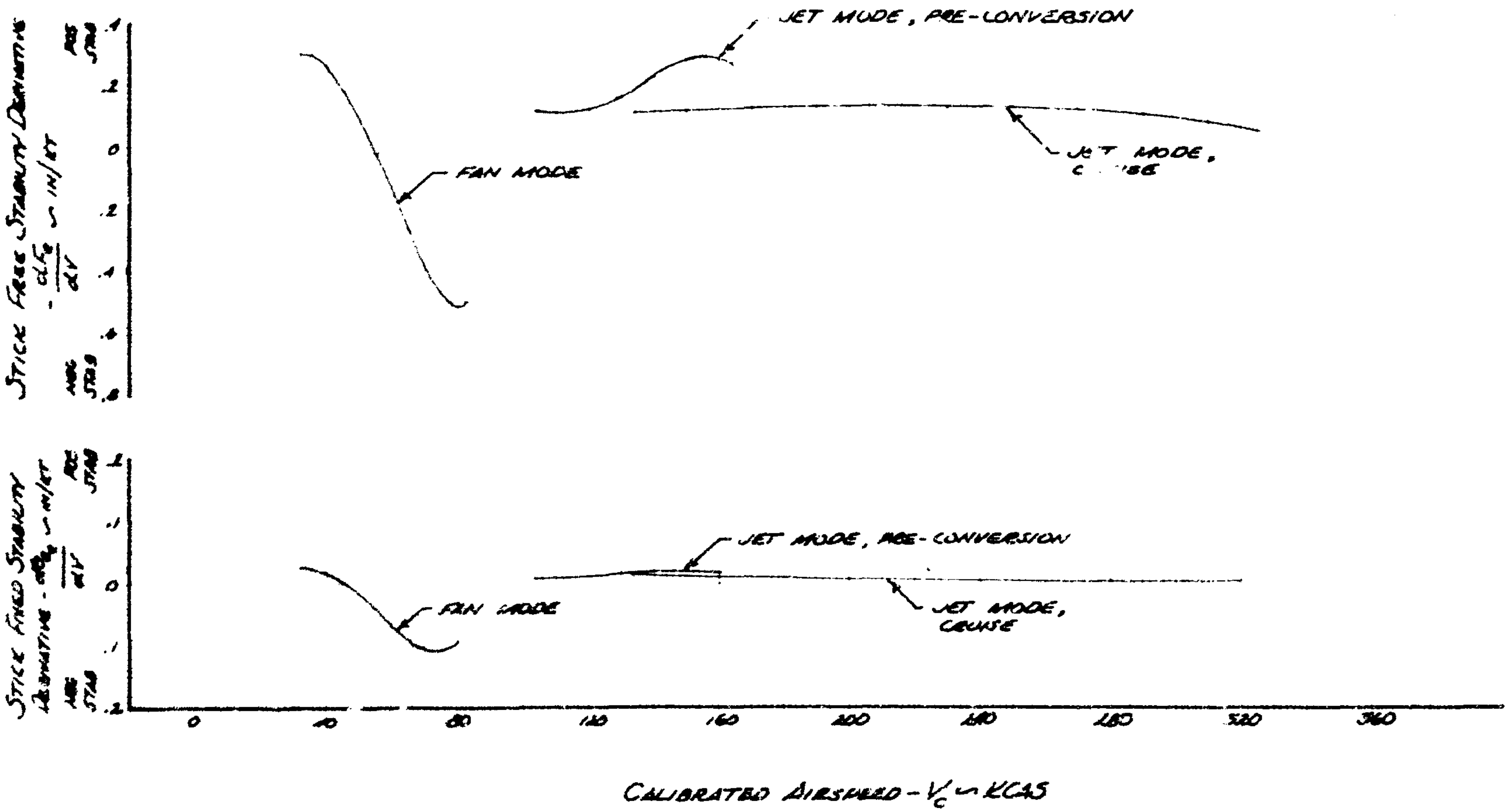


FIGURE No. 139
SUMMARY OF STATIC DIRECTIONAL
STABILITY DURING TRANSITION

CONFIGURATION	GROSS WT. ~ LB	PRESSURE ALT ~ FT.	C.G LOC ~ IN	GEAR POS.	FLAP. POS. ~ DEG
FAN MODE	8830	5700	241 (MID)	DOWN	45
JET MODE (P.C.)	10300	5300	241.5(MID)	UP & DOWN	45
JET MODE (CR.)	10000	9500	241.5(MID)	UP	0

CURVES DERIVED FROM FIGURE NO.

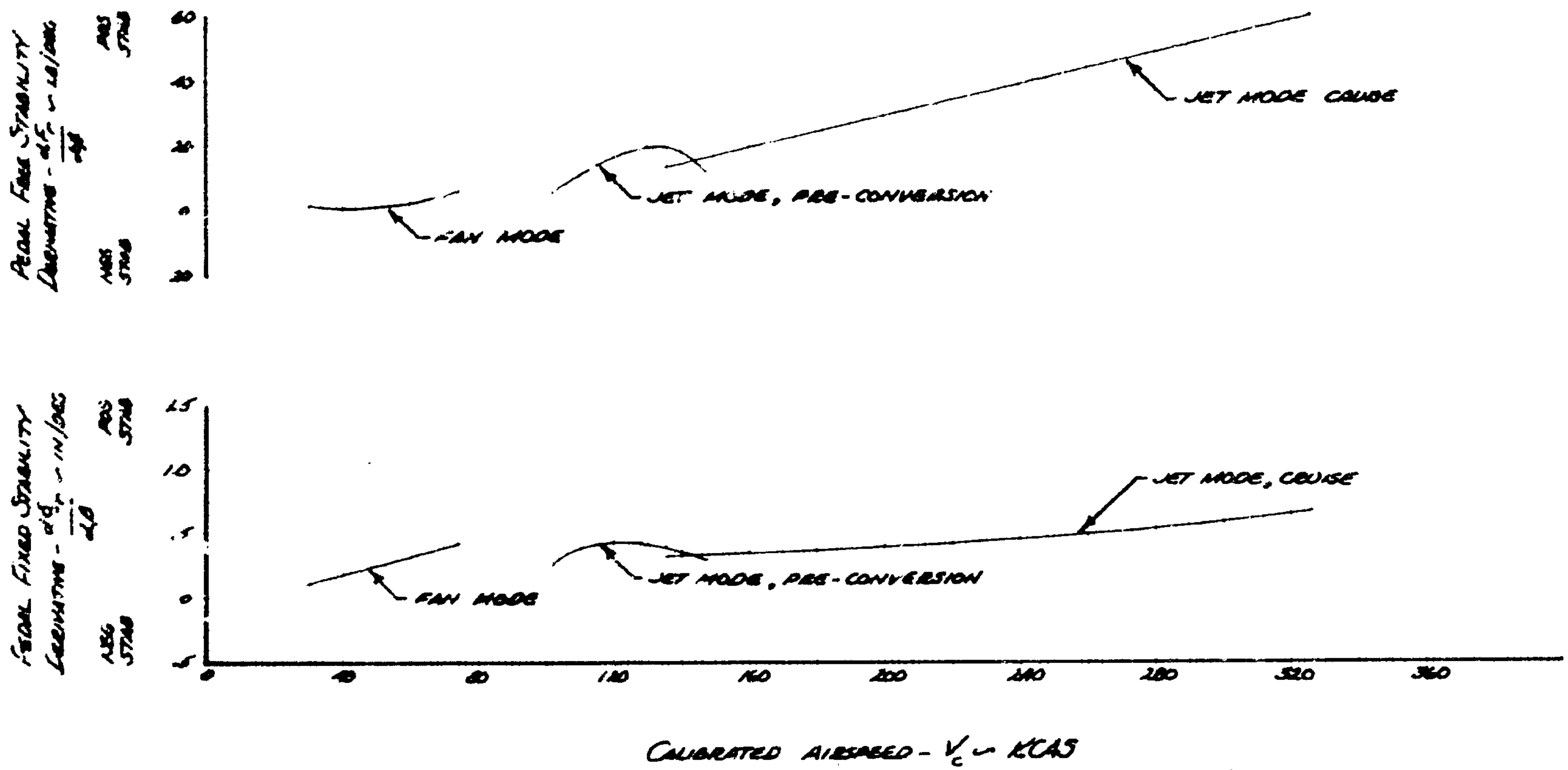
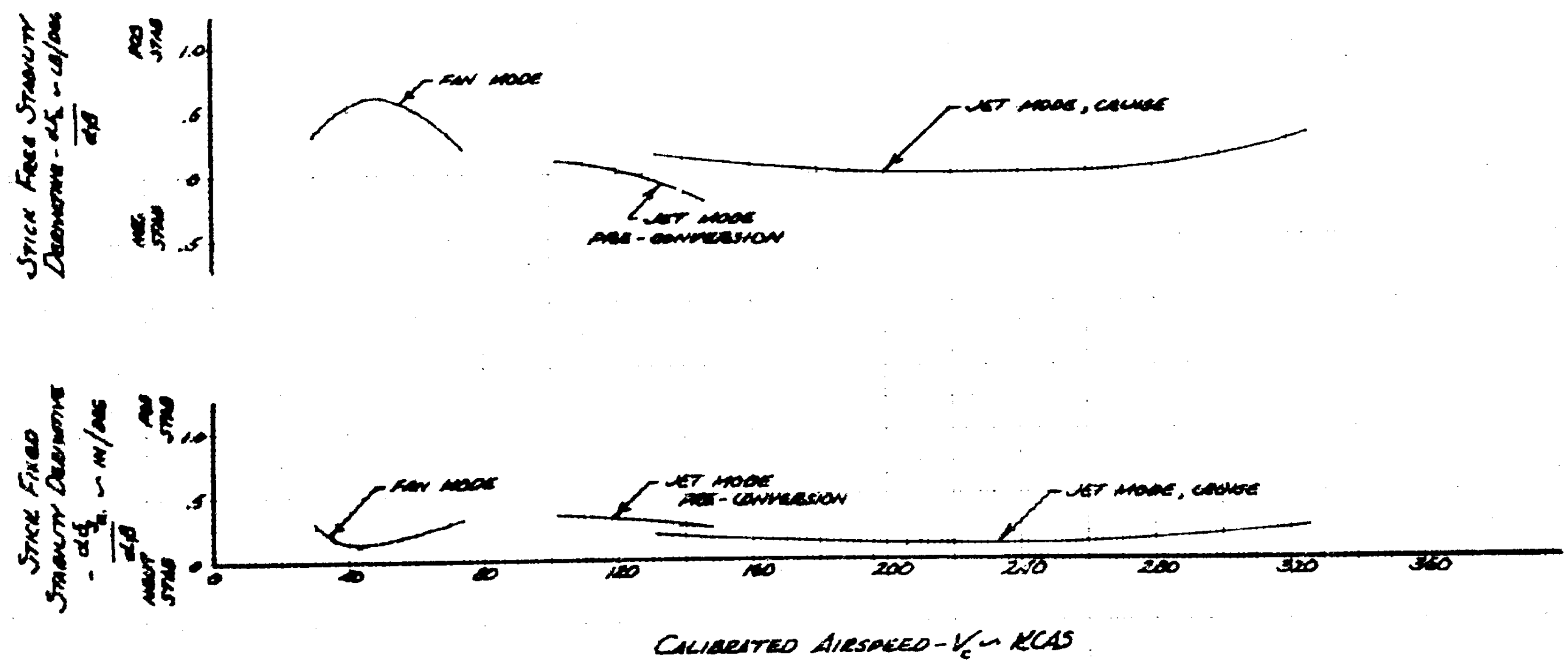


FIGURE No. 140

SUMMARY OF EFFECTIVE DIHEDRAL DURING TRANSITION

CONFIGURATION	GROSS WT ~ LB	PRESSURE ALT ~ FT	C.G. LOC. ~ IN	GEAR POS.	FLAP POS. ~ DEG.
FAN MODE	8880	5700	241 (MID)	DOWN	45
JET MODE (P.C)	10300	5300	241.5 (MID)	UP & DOWN	45
JET MODE (CR)	10000	8500	241.5 (MID)	UP	0

CURVES DERIVED FROM FIGURE NO



APPENDIX II

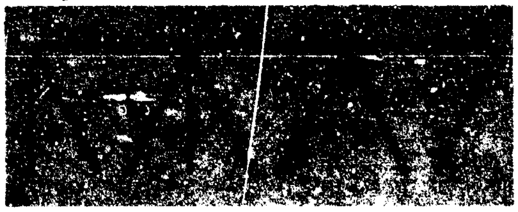
DEFINITIONS, SYMBOLS AND ABBREVIATIONS

1.0 DEFINITIONS

Fan Mode (FM)	Flight condition in which any part of the vertical lift is provided by the wing fan.
Jet Mode (JM)	Flight condition in which the vertical lift is entirely aerodynamic.
Hover	Fan-Mode flight less than 30 knots in any direction.
STOL	Takeoff or landing which is accomplished with a combination of wing-fan lift and wing aerodynamic lift.
Translation	Flight through all fan-mode configurations to conversion.
Conversion	That portion of the flight that encompasses the action of changing from one flight mode to the other (jet to fan or fan to jet).
Pre-conversion	That portion of the flight in which the lift is purely aerodynamic and the aircraft is preparing to perform a conversion from jet mode to fan mode. The configuration is as follows: Flaps 45 deg, fan doors unlocked but closed, louvers maximum aft (45 deg), pitch-fan doors and vanes open.
Transition	Flight through all the configurations and regimes from vertical lift-off (fan mode) to jet flight (jet mode) and return.

Louver Stagger Angle (β_s)

The difference in angle between the master even and odd louver for each wing.



$$\beta_s = A - B$$

Louver Vector Angle (β_v)

The sum of the 4 master louvers (2 each wing) divided by 4.

$$\beta_v = \frac{A + B + C + D}{4.0}$$

Differential Beta Vector ($\Delta\beta_v$)

The sum of the 2 master louvers on the right wing subtracted from the sum of the 2 master louvers on the left wing.

$$\Delta\beta_v = (A + B) - (C + D)$$

Differential Stagger Vector ($\Delta\beta_s$)

The difference between the 2 master louvers on the right wing subtracted from the difference between the 2 master louvers on the left wing.

$$\Delta\beta_s = (A - B) - (C - D)$$

2.0 SYMBOLS AND ABBREVIATIONS

	Nomenclature	Units
C.G.	Center of Gravity	in
F_a	Lateral Stick Force	lb
F_e	Longitudinal Stick Force	lb
F_r	Rudder Pedal Force	lb
KCAS	Knots Calibrated Airspeed	
KEAS	Knots Equivalent Airspeed	
KIAS	Knots Indicated Airspeed	
KTAS	Knots True Airspeed	
M_y	Pitching Moment	in. lb
M_x	Rolling Moment	in. lb
M_z	Yawing Moment	in. lb
N_f	Wing-Fan RPM	rpm (%)
N_j	Jet Engine RPM	rpm (%)
N_p	Pitch-Fan RPM	rpm (%)
OGE	Out of Ground Effect	lb/in^2
P_a	Ambient Pressure	in. Hg
P_{SL}	Sea Level Pressure, 2116.1 lb/ft^2	lb/ft^2
q	Dynamic Pressure	lb/in^2
R/C	Rate of Climb	fpm
S	Wing Area	ft^2
SAS	Stability Augmentation System	
T_a	Ambient Temperature (FAT)	deg K

t_{ic}	Indicated Ambient Temperature	deg C
t	Time	sec
V_c	Calibrated Airspeed	kt
V_e	Equivalent Airspeed	kt
V_i	Indicated Airspeed	kt
V_{ic}	Instrument Corrected Indicated Airspeed	kt
V_T	True Airspeed	kt
W_t	Test Gross Weight	lb
α	Angle of Attack	deg
β	Angle of Sideslip	deg
β_s	Louver Stagger Angle	deg
β_v	Louver Vector Angle (Sum of 4 Master Louvers/4.0)	deg
$\Delta\beta_v$	Differential Beta Vector (Fan Yaw Control)	deg
$\Delta\beta_s$	Differential Beta Stagger (Fan Roll Control)	deg
Δ	Difference	
δ_a	Aileron Angle	deg
δ_c	Collective Position	deg
δ_e	Elevator Angle	deg
δ_{pfd}	Pitch-Fan Thrust Reverser Door Position	deg
δ_r	Rudder Angle	deg
δ_{s_a}	Lateral Stick Position	in
δ_{s_c}	Collective Stick Position	in

δ_{s_e}	Longitudinal Stick Position	in
δ_{s_r}	Rudder Pedal Position	in
θ	Pitch Angular Displacement	deg
$\dot{\theta}$	Pitch Angular Velocity	deg/sec
$\ddot{\theta}$	Pitch Angular Acceleration	deg/sec^2
ρ	Air Density	$slugs/ft^3$
σ	Density Ratio	
ϕ	Roll Angular Displacement	deg
$\dot{\phi}$	Roll Angular Velocity	deg/sec
$\ddot{\phi}$	Roll Angular Acceleration	deg/sec^2
Ψ	Yaw Angular Displacement	deg
$\dot{\Psi}$	Yaw Angular Velocity	deg/sec
$\ddot{\Psi}$	Yaw Angular Acceleration	deg/sec^2

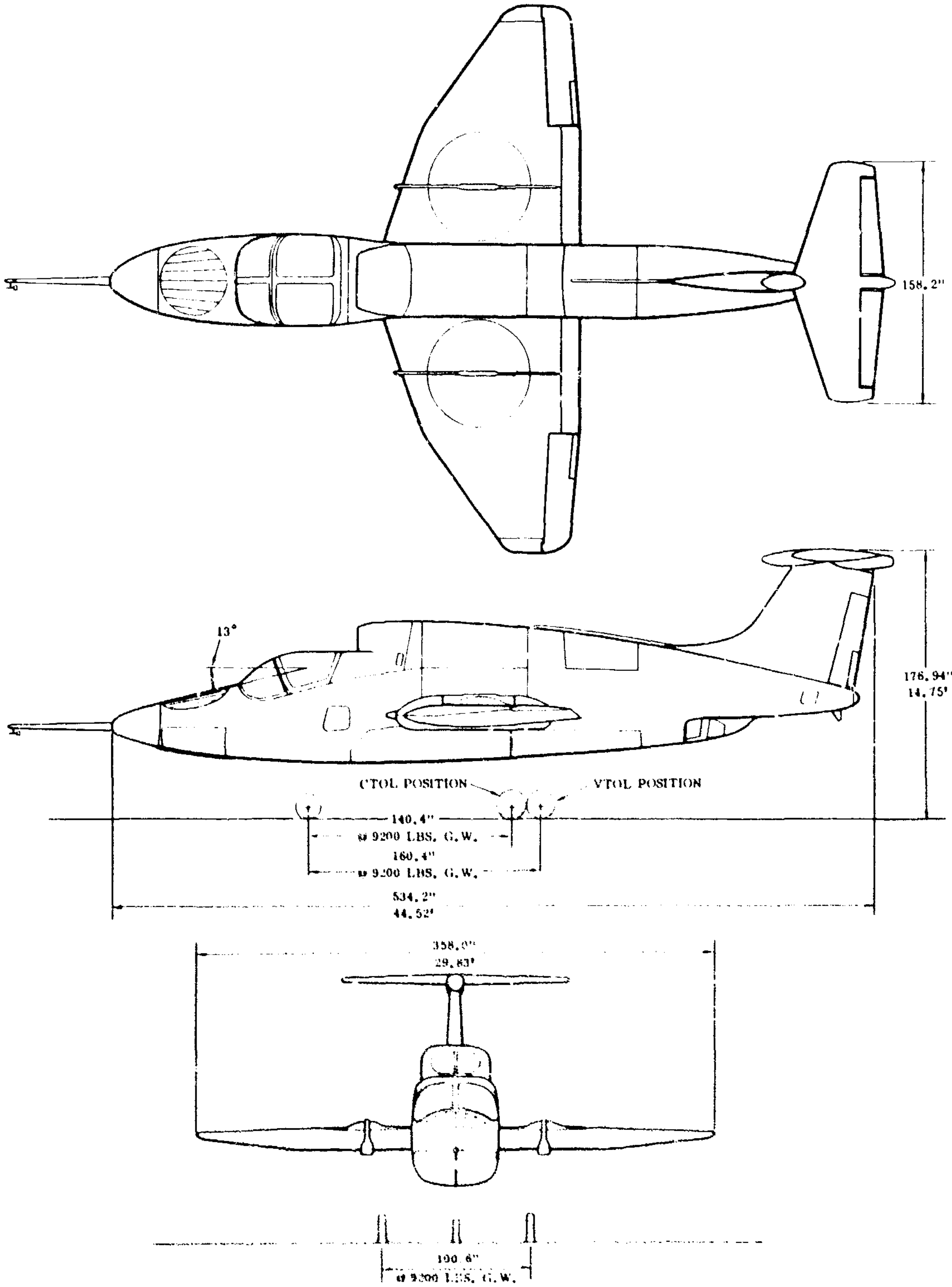


FIGURE 1 - XV-5A Dimensions

APPENDIX III

GENERAL AIRCRAFT INFORMATION

1. SOURCE OF INFORMATION

The descriptive and design information in the following paragraphs was obtained from "XV-5A Detail Aircraft Specification" (Reference o).

2. DESCRIPTION OF AIRCRAFT AND SYSTEMS

2.1 DIMENSIONS AND DESIGN DATA

a. Areas

(1)	Wing area (including 49 sq ft of fuselage)	260.3 ft^2
(2)	Vertical tail area	51.0 ft^2
(3)	Flap area	25.4 ft^2
(4)	Aileron area (aft of hinge line), total	19.3 ft^2
(5)	Horizontal tail area, total	52.9 ft^2
(6)	Elevator area (aft of hinge line), total	12.0 ft^2
(7)	Vertical tail area, total	51.0 ft^2
(8)	Rudder area (aft of hinge line), total	6.4 ft^2
(9)	Wing-fan annulus area, total	35.6 ft^2
(10)	Wing-fan area (fan tip), total	42.6 ft^2
(11)	Pitch-fan annulus area, total	5.64 ft^2

b. Wings

(1)	Span	29.83 ft

(2) Chord

(a) Root 12.08 ft

(b) At break in quarter chord 9.09 ft

(c) Theoretical tip 3.58 ft

(d) Mean aerodynamic (MAC) 9.41%

(3) Sweep at 1/4 chord

(a) Inboard panel 15.0 deg

(b) Outboard panel 28.3 deg

(4) Airfoil section

At butt line (BL) 170.05 NACA 0012-24

(5) Aspect ratio 3.42

c. Ailerons

(1) Span 6.37 ft

(2) Chord 32.7%

(3) Centroid of aileron area BL-139.6 in

d. Flaps (single slotted)

(1) Span 43.0%

(2) Chord (average) 19.6%

e. Horizontal tail

(1) Span 13.18 ft

(2) Chord

(a) Root 65.64 in

(b) Tip 30.60 in

(3) Sweep of leading edge 19.5 deg

	(4) Airfoil section	NACA 64A012
	(5) Aspect ratio	3.29
	(6) Pivot point	Fuselage Station (FS)-496.7
	(7) Distance of 1/4 MAC from wing 1/4 MAC	21.17 ft
f.	Elevators	
	(1) Span (per side)	5.47 ft
	(2) Chord	
	(a) Root (BL 4.3)	1.337 ft
	(b) Tip (BL 69.9)	.854 ft
	(3) Location of 1/4 MAC	FS-521.1 in
g.	Vertical tail	
	(1) Sweep of leading edge	35.4 deg
	(2) Airfoil section	
	(a) Waterline (WL) 113.0 in	NACA 64A(012)-016.5
	(b) WL 206.0 in (tip)	NACA 64A(012)-013.0
	(3) Aspect ratio	1.178
	(4) Distance of 1/4 MAC to wing 1/4 MAC	18.25 ft
h.	Rudder	
	(1) Span	5.20 ft
	(2) Chord	
	(a) Root	1.47 ft
	(b) Tip	.98 ft

(3) Location of 1/4 MAC — FS-507.4 in

(4) Height over highest point of vertical tail (reference line level) — 14.75 ft

(5) Length (reference line level) — 44.52 ft

2.2 CENTER-OF-GRAVITY LOCATIONS

Aft limit	FS-246 in
Forward limit	FS-240 in

2.3 CONTROL MOVEMENTS

The movements measured during the test program:

a. Longitudinal control stick — 6.5 in. fwd
6.0 in. aft

b. Lateral control stick — 3.90 in. rt
3.20 in. lt

c. Rudder pedal — 3.50 in. lt
3.50 in. rt

d. Elevator surface (from faired position) — 22 deg trailing edge up(TEU)
25 deg trailing edge down (TED)

e. Left aileron surface position

(flaps at zero deg)	18 deg TEU	15.75 deg TED
(flaps at 45 deg)	7.75 deg TEU	26.25 deg TED

f. Right aileron surface position

(flaps at zero deg)	18.9 deg TEU	15.25 deg TED
(flaps at 45 deg)	7.25 deg TEU	25.75 deg TED

g. Rudder surface position

24.5 deg trailing edge right (TER)

24.75 deg trailing edge left (TEL)

h. Horizontal stabilizer

20 deg leading edge up (LEU)

5 deg leading edge down (LED)

i. Flaps (zero %)	zero deg	
(100%)	45 deg	
j. Pitch-fan modulator doors (-10.5 deg beta vector)		65 deg
k. Wing-fan roll control (differential stagger)		32.0 deg lt
(-10.5 deg beta vector)		37.5 deg rt
l. Wing-fan yaw control (differential vector)		31.0 deg lt
(-10.5 deg beta vector)		31.6 deg rt
m. Wing-fan beta vector		-10.5 deg
		+38.7 deg

2.4 AIRCRAFT SYSTEMS

2.4.1 FLIGHT CONTROL SYSTEM

The pilot is provided with conventional flight controls, fan-mode (FM) flight controls and control elements required for conversion from one flight mode to another. The primary flight control system consists of a control stick for conventional longitudinal and lateral control, a collective lift stick and rudder pedals for directional control. In addition to necessary instrumentation, the pilot is provided with a power console and an auxiliary console. The auxiliary console is used in conjunction with other controls to accomplish conversion from one flight mode to another.

The control stick is mechanically connected to the aerodynamic flap-type control surfaces, wing-fan exit-louver servo valves, and pitch-fan thrust modulator servo valve. The lift stick is connected to the wing-fan exit-louver servo valves and is operative only during fan-mode flight. The rudder pedals are mechanically linked to the conventional rudder as well as to

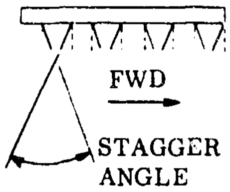
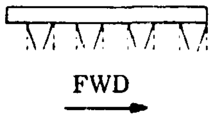
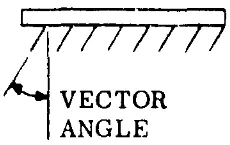
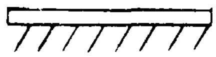
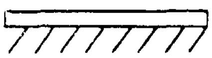
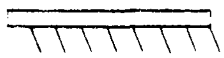
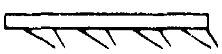
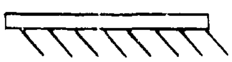
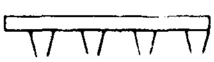
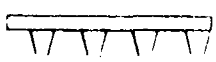
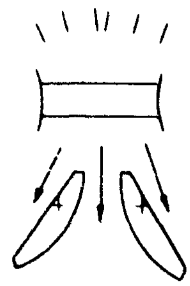
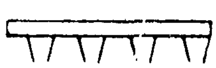
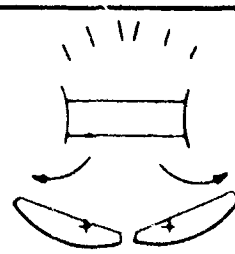
the wing-fan exit-louver servo valves. The ailerons, wing-fan exit-louvers and pitch-fan thrust modulators are hydraulically actuated. In addition to being mechanically controlled, the wing-fan exit-louver servo valves and the pitch-fan thrust-modulator servo valve have electrical features which accept input signals from the stability augmentation system (SAS) amplifiers.

The control stick and rudder pedals perform identical attitude control functions in both conventional and FM flight. Longitudinal stick motion controls the elevators and the pitch-fan thrust-modulator doors. Lateral stick motion controls the ailerons as well as the differential stagger of the wing-fan exit louvers. In FM flight, the collective lift stick motion adjusts the wing-fan louver collective stagger and the position of the pitch-fan modulator doors.

A mechanical mixer mechanism is installed between the cockpit controls and the louver actuator valves. This mechanical mixer mechanism interprets pilot commands and positions the wing-fan exit louvers. The mixer also decreases and eventually disengages the wing-fan louver response to pilot commands as a function of louver vector angle (forward speed). This deactivates the wing-fan control system while in the conventional mode. A similar device combines longitudinal control and collective control commands to the pitch-fan thrust-modulator doors and disengages door response to commands as a function of louver vector angle. Another function of the mixer is to compensate for rolling tendencies when yaw commands are given.

In the FM flight, the positions of the wing-fan louvers (see Figure 2) determine beta stagger or vector, either collective or differential, or combinations of both. Thus, the beta stagger angle of the louvers determines the lift of each wing fan for roll, lift control and trim, whereas the vector angle of the louvers determines the horizontal thrust component of the wing. Combinations of these two angles, either collective

FIGURE 2 - VTOL Flight Control System Operation

RIGHT FAN	LEFT FAN	NOSE FAN	FUNCTION
			LIFT - COLLECTIVE STAGGER
			ACCELERATION CONTROL - COLLECTIVE VECTOR
			DIRECTIONAL TRIM & CONTROL - DIFFERENTIAL VECTORING
			LATERAL TRIM AND CONTROL - DIFFERENTIAL STAGGER
			PITCH TRIM AND CONTROL (NOSE UP)
			PITCH TRIM AND CONTROL (NOSE DOWN)

or differential, result from pilot inputs and/or automatic stabilization of the roll and yaw axes within the limited authority of the SAS system. These control functions are summarized as follows:

a. Collective stagger produces vertical deceleration.

b. Differential stagger produces roll control.

c. Collective vector produces horizontal acceleration.

d. Differential vector produces yaw acceleration.

For the pitch axis, the pitch-fan modulator doors increase or spoil the thrust of the pitch fan. In a manner similar to the roll and yaw-axis control of the wing louvers, the hydraulic actuator for the pitch-fan doors responds to the pilot's input and/or any signal generated by the pitch-rate gyro of the SAS system.

2.4.2 FLIGHT CONTROL ELECTRICAL SYSTEM

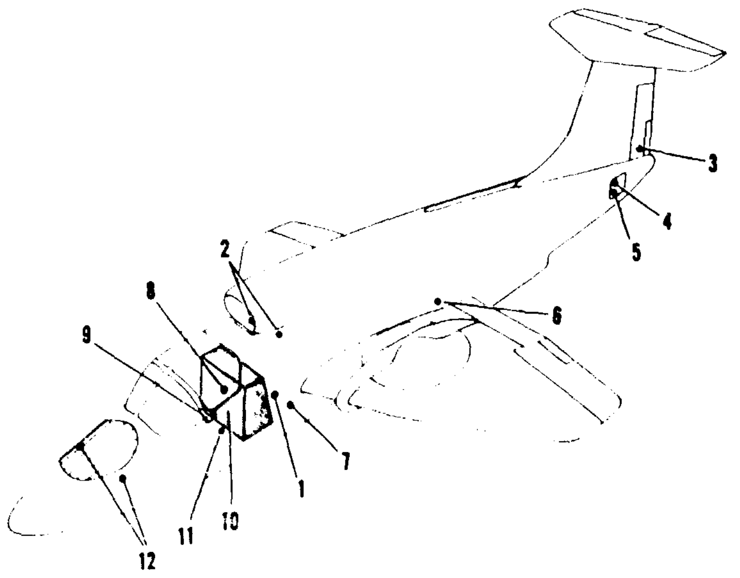
Electrical power is supplied by two 28-volt-DC, 165-ampere engine-driven generators and a silver-zinc battery for emergency use. Two inverters supply 115-volt, 440-cycle AC power. If a power loss is realized in one inverter, electrical loads are automatically transferred to the other inverter. Either inverter is capable of supplying normal current loads.

The conversion control and SAS have dual electrical channels for both primary and standby functions. Both primary and standby circuits are energized; however, only one circuit controls at a time. Command signals for conversion and sequencing are always dual except for flaps and ailerons droop commands. All commands are fed to the electrical mixer for conversion control, and the electrical mixer integrates and selects the proper flight control actuator valves. The SAS is inoperative during jet-mode (JM) flight. Special electrical features of the conversion control system include automatic lockout during conventional flight and while the aircraft is hovering in the FM flight.

In JM flight, control functions of the flaps-down switch are selected through the louver selector switch which has two positions, either JM or FM. If the louver selector switch is in the JM position, flaps-down command causes flaps down with aileron droop conditions. If the louver selector switch is in the FM position, the same occurs and, in addition, sequenced preconversion functions of the pitch-fan inlet louvers and wing-

fan door locks and vectoring of the wing-fan louvers occur. When these operations are completed, monitoring switches act as an interlock through the mode selector switch and the electrical mixer. The circuitry is arranged so that the mode selector switch cannot command conversion to the FM configuration unless all pre-conversion conditions have been met. If the conditions have not been met on either primary or standby systems, the electrical interlock system causes an interlock "No Go" warning light to illuminate the annunciator panel.

In FM flight in hover, immediate change to JM cannot be made. The pilot's maneuvering to gain a safe airspeed causes a series of sequenced, automatic electrical events to occur. When the fan louver vectoring is sufficient to provide a safe airspeed, the mode selector switch capability is restored to the pilot. At this time, the JM command can be given to the electrical mixer, if desired, and an interlocked sequence of electrical commands is automatically given. These commands include change in angle of attack of the stabilizer, diversion of gases to the tailpipe,



1. Louver Roll Trim and Louver Yaw Trim Actuators
2. Generators
3. Rudder Trim Tab Actuator
4. Battery
5. Inverters
6. Flap Actuator
7. Louver Vectoring Actuator
8. Electrical Flight Control Mixer Box
9. External Power Receptacle
10. Electrical Equipment Compartment
11. Nose-Fan Pitch Trim Actuator
12. Nose-Fan Inlet Door Actuators

FIGURE 3 -Electrical System Component Location Diagram

closure of the wing-fan doors and de-activation of the SAS. When these automatic electrical commands to the actuators have been completed, the aircraft is the same pre-conversion configuration as before converting from JM flight to FM flight.

If an actuator failure occurs during any part of pre-conversion or pre-conversion sequence (JM to FM), or if any mechanical interruption occurs in the procedure, the Interlock "No Go" warning light notifies the pilot that he should not change mode. The circuitry is arranged so that a definite sequence has to be followed by the pilot. Similarly, any electrical, hydraulic or mechanical failure causes an interlock channel to be given, thus interrupting the sequence and causing the warning to be displayed on the annunciator panel.

2.4.3 FLIGHT PROPULSION SYSTEM

This system consists of two J85-5B turbojet engines (less afterburners) used as gas generators; diverter valves to direct the gas flow; two X353-5B lift fans equipped with vectorable discharge louvers; one X376 pitch-trim control fan and necessary ducting. The system augments the thrust of the turbojet engines for FM flight.

For vertical flight, the turbojet engines supply hot exhaust gas to the tip turbines of the wing fans. This is accomplished by means of a diverter valve and ducting. During transition from hover to horizontal flight, louvers (located on the lower surface of the fan) vector the fan exhaust rearward to provide horizontal thrust for forward acceleration. Once the aircraft has reached a speed sufficient for wing supported flight, the diverter valve moves to a straight-through position, the exit louvers and the wing-fan doors are closed, and the turbojet operates in the conventional manner. Crossover ducting between the wing fans provides for single-engine operation.

The pitch fan, installed in the nose of the aircraft, provides longitudinal attitude control of the aircraft during FM operation. The pitch fan is coupled to the gas generators in a manner similar to that of the wing fans. Pitch control is obtained by modulation of the pitch-fan control doors, which respond to the pilot's input and/or any SAS signal during FM flight. The doors are closed and locked for JM flight.

In JM flight, the engine compartment is cooled by ram air, which in turn is exhausted by the tailpipe shroud ejector. In the hover mode, cooling air is supplied for four engine-driven fans. The heated air is then exhausted from the forward pitch-fan duct

compartment through outlets in the pitch-fan (inlet) struts. The divider-duct and wing-fan compartments are exhausted from the strut fairings of the wing fans.

The aircraft is provided with a conventional throttle quadrant, and in addition a twist grip is incorporated on the collective lift control; this affords joint regulation of engine power when in the FM flight.

2.4.4 FLIGHT CONTROL HYDRAULIC SYSTEM

Two independent hydraulic systems are provided for flight control. Each system operates continuously and consists of separate reservoirs, engine-driven pumps and plumbing. Either system is capable of supplying full load requirements in case of pressure loss in one system. Hydraulic power is provided to operate the wing-fan inlet doors and exit louvers, pitch-fan doors, horizontal stabilizer, thrust spoilers and ailerons.

The wing-fan exit-louver servo valves and the pitch-fan thrust-modulator servo valve are controlled not only by mechanical inputs, but also by an electrical input feature capable of accepting input signals from the SAS amplifiers. Hydraulic actuators also position the thrust spoilers and the ailerons. A hydraulic motor-driven screw jack positions the horizontal stabilizer.

Pressure transmitters for each hydraulic system operate a dual-reading hydraulic pressure gage located in the cockpit. In case of system pressure loss, an annunciator warning panel indicates the affected system to the pilot. Normal hydraulic system pressure is 3000 pounds per square inch. Ground test connections are provided for system checkout and to facilitate filling.

2.4.5 ENGINES

The J85-5B engines, located in the upper fuselage above the wing and aft of the cockpit, are axial-flow turbojets used as gas generators. Uninstalled rating per engine is as follows:

	Jet Thrust lb (min)	Engine Compressor rpm (max)
Sea level rated power	2500	16,500

Major components of each engine include an 8-stage rotor, a matching compressor stator, an annular combustion system, and a 2-stage turbine.

Air enters the inlet duct and is directed into the inlet compressor by the variable inlet guide vanes. As the air is compressed, it is forced back into the combustion chamber. Fuel nozzles, projecting into the combustion chamber, eject a fuel spray which is mixed with the compressed air. Combustion is provided initially by the ignition plug but is self-sustaining thereafter. The combustion gases flow into the 2-stage turbine mounted on a shaft that is splined directly to the compressor rotor. After passing through the turbine section, the exhaust gases flow into the diverter valve ducts, where the gases are diverted either to the wing-fan/pitch-fan propulsion system (for FM flight), or to the engine tailpipe (for JM flight).

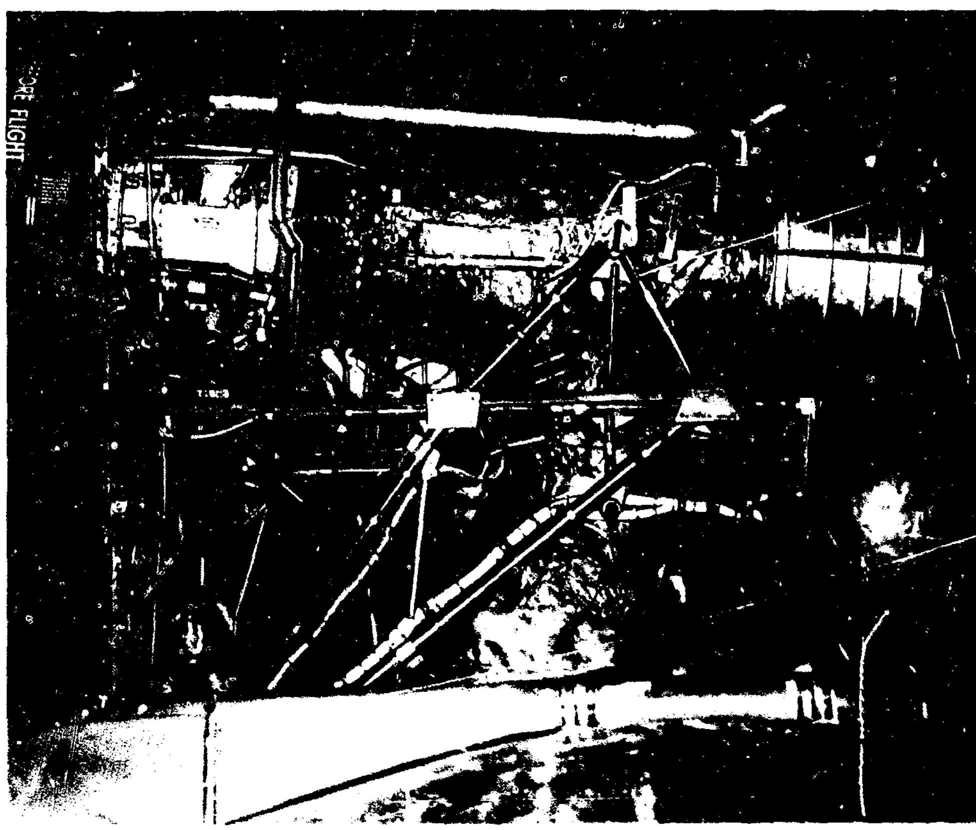


PHOTO 11 - LEFT HAND SIDE DIVERTER VALVE INSTALLED IN XV-5A

Major component details include a 15-strut front frame fabricated of sheet metal, with 15 variable-pitch inlet guide vanes positioned directly downstream of the struts. An anti-icing manifold surrounds the front frame over the hollow struts. The compressor stator casing is split and flanged along the horizontal centerline; this makes it possible to remove the upper or lower half for inspection. The 8-stage axial-flow compressor delivers air to the combustion section at a pressure

ratio of approximately 6.8 to 1. The compressor casing is made of chromalloy steel. The external cylindrical part of the main frame is also a chromalloy steel weldment. The frame not only serves as a structural member but houses the power-takeoff drive assembly and provides a mount for the 12 flow-divider fuel nozzles, the fuel manifold, the accessory drive gearbox assembly and the 8-stage compressor stator vanes and exit guide vanes. Six equally-spaced struts provide for extraction of compressor discharge air for auxiliary pressurization use. The outer combustion casing is a one-piece stainless steel weldment that serves as a major structural unit. The inner combustion casing is also a one-piece fabrication. The turbine stator is a sheet metal weldment with a horizontal split line which permits removal of either half for inspection. The air impingement start duct is located on the bottom half of the casing. The turbine rotor is a 2-stage impulse type which was designed to operate at a speed of 16,500 rpm and at a nominal turbine inlet temperature of 1650 degrees F.

Lubrication is provided by a pressurized, closed-circuit system which furnishes oil to the cored and drilled passages of the engine and to a relatively few external oil lines. The lubrication system is pressurized by bleeding compressor air into the oil reservoir. A relief valve prevents excessive pressure.

For engine ignition, a capacitor discharge ignition unit is provided. The engine igniter plug is immersed in the combustor. Alernating current (AC) of 115 volts, 400 cycles is produced by an airframe-mounted inverter. The current passes through a filter which prevents high frequency signals from entering or leaving the unit. The input power is stepped up to approximately 1250 volts by a transformer, then rectified to a pulsating direct current (DC) potential of about 2500 volts, which is stored in the capacitor. A sealed gap allows periodic surges of stored high DC voltage to flow to the igniter. Once ignition has been accomplished, combustion of the engine is self-sustaining.

The overspeed governor is hydro-mechanical isochronous type which senses and governsengine physical speed at one adjustable speed setting by bypassing fuel flow in excess of engine requirements to the main fuel pump inlet. The overspeed governor system provides a limit steady-state engine speed of 104 percent maximum and a limit transient speed of 108 percent maximum.

2.4.6 FUEL SYSTEM

The fuel system is controlled by the pilot at the fuel management panel. The panel represents the plumbing of the entire

fuel system in diagram. For normal operation, the 1710-pound-capacity forward tank supplies fuel to the left engine. The 1720-pound-capacity aft tank supplies fuel to the right engine. The normal setting for the fuel tank valves is to have both tank-to-engine valves open. The fuel level of each tank is shown on the main instrument board by a dual gage in the engine display. Low level in either tank lights the master caution light and a low-level light in the annunciator panel. The tank affected is indicated by low-level amber lights on the fuel management panel and when this occurs approximately 250 pounds of fuel remain.

Each tank is equipped with a boost pump, driven by engine bleed air. The pump is controlled by a switch on the fuel management panel. Caution lights for the boost pumps indicate low pressure or loss of pressure. The boost pumps are used for all engine operations; however, the engine pumps will maintain engine operation below 6000 feet altitude.

2.4.7 STABILITY AUGMENTATION SYSTEM

The stability augmentation system (SAS) operates in the FM flight during transition and conversion and stabilizes the aircraft attitude in all axes. During conventional flight, the SAS system is inoperative. Dual electronic channels provide for both primary and standby systems. The systems consist of the pilot controls, dual 3-axis gyros and dual amplifiers. The 3-axis rate-gyro signals determine the hydraulic actuator positions of the wing-fan louvers and the pitch-fan (modulator) doors. The two systems are identical except for the gain control. The primary system gains are adjustable by the pilot at the instrument panel. In normal flight, the primary system is used and back-up reliability is supplied by the standby system.

The automatic stabilization electrical inputs of the SAS system are summed with the mechanical inputs in both the wing-fan louver and pitch-fan door actuators. The response of these actuators to the electrical signals is such that each actuator has limited authority in case a hardover signal occurs. In the roll axis, the amplifier operates in either a holding or maneuvering mode, depending upon the position of the control stick. For small motions near the center of the control stick travel, the amplifier operates in the holding mode. In this case, the gyro signal is integrated to produce a quasi-position signal which is combined with the rate signal. For larger excursions (± 1 inch) of the control stick, switches located on the control linkage cause the integrator in the amplifier to be shorted, and the amplifier operates in the maneuvering mode. In this mode, the quasi-position signal is eliminated and only the rate signal

is amplified and sent to the actuators. The pitch and yaw axes operate in the maneuvering mode at all times. There is no integration of the rate signal; however, a change of gain is effected by displacing the controls.

The settings and authority of the optimum SAS configuration used during the tests were:

Collective Stick Position δ_{s_c} - % Up	Vector Angle β_V - deg	Stability Augmentation System Authority - ΔSAS Equivalent Inches of Control		
		Pitch ΔSAS_e - in	Axis Roll ΔSAS_a - in	Yaw ΔSAS_r - in
50	0	2.09	.70	1.55
100	0	1.65	.70	1.58
	15	2.27	1.07	1.61
	30	2.03	2.07	2.05

FIGURE 4- AUTOMATIC STABILIZATION SYSTEM BLOCK DIAGRAM, page 286

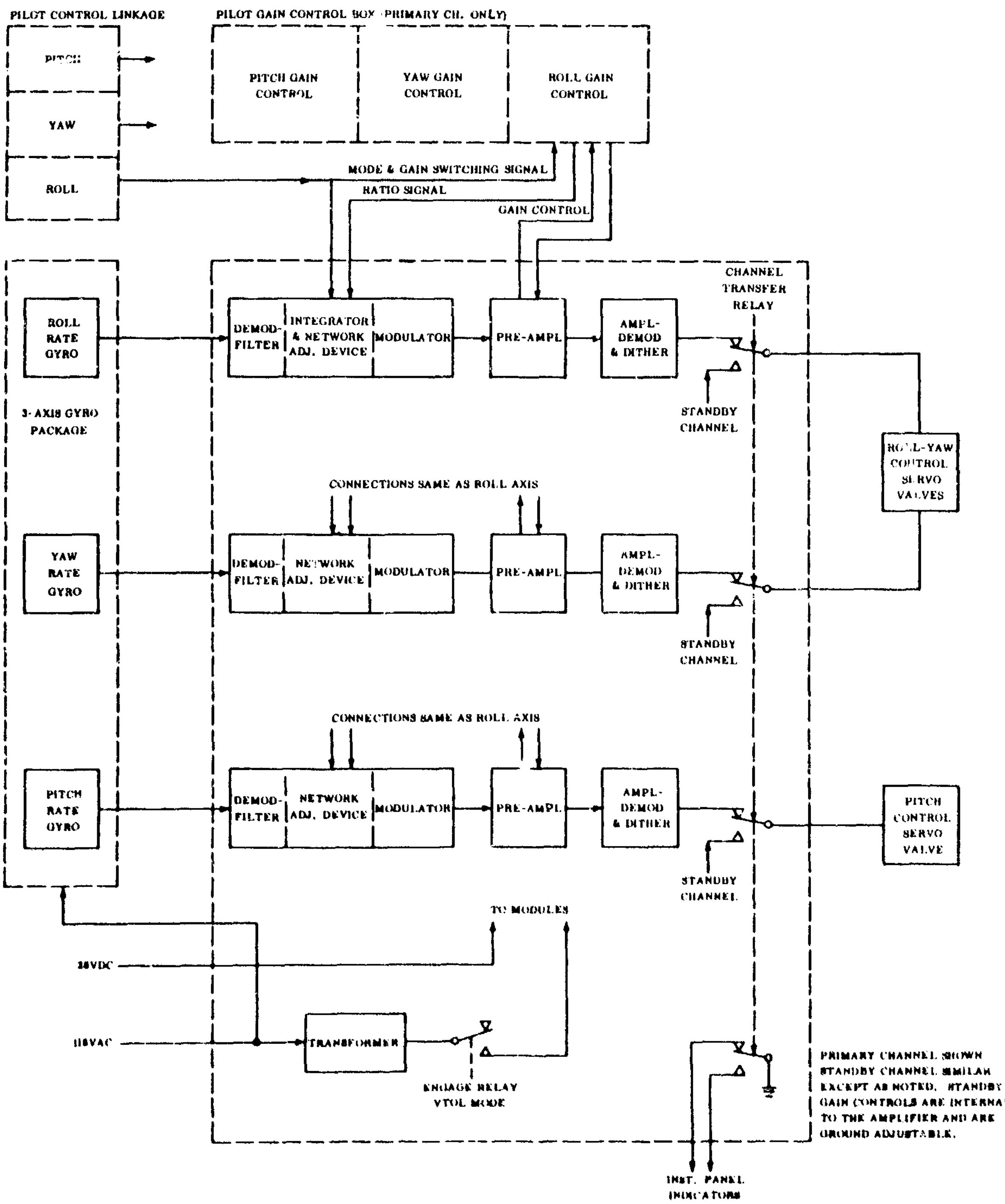


FIGURE 4 - Stability Augumentation System Block Diagram

APPENDIX IV

FLIGHT AND OPERATION LIMITS

The following flight and operation limits were observed during the stability and control evaluation of the XV-5A aircraft:

a. Airspeed Limitations

(1) Jet-Mode Flight

(a) Maximum Flight Speed - Figure 1

The maximum flight speed was 400 knots equivalent airspeed (KEAS) or 0.70 Mach Number based on flutter and stability and control flight tests.

The aircraft was limited to 300 knots indicated airspeed (KIAS) or 0.70 Mach Number pending further evaluation of the fuel tank vent system.

(b) Wing Flap, Landing Gear, Pitch-Fan Inlet Louver, Pitch-Fan Exit Door or Wing-Fan Exit Louver Extension (or Extended).

Maximum structural speed - 180 KEAS

(c) Pre-conversion Configuration

Maximum structural speed	180 KEAS
Maximum speed, Phase II flight test policy	130 KIAS

(d) Low Airspeed System

Maximum design speed, aircraft system	170 KIAS
Maximum design speed, flight test instrumentation system	150 KIAS

(e) Nose Landing Gear Critical Speed (Shimmy Damper Limit)

Maximum - 120 knots ground speed

(f) High Speed Drag Parachute

Maximum design deployment speed	500 KEAS
Minimum design deployment speed	150 KEAS

(g) Landing Deceleration Parachute

Maximum design deployment speed	130 KEAS
Minimum design deployment speed	70 KEAS

(h) Spin Recovery Parachute

Maximum design deployment speed	180 KEAS

(i) Minimum Flight Speed

Minimum speed = that speed at which 15 deg indicated angle of attack occurs

(2) Fan-Mode Flight

(a) Conversion Speed Limits

Turbojets to fans	92 to 110 KIAS
Fans to turbojets	84 to 95 KIAS

(b) Maximum Flight Speed

Maximum design speed	120 knots true airspeed (KTAS)
Maximum demonstrated speed	110 KIAS (approximate)

(c) Minimum Flight Speed At Altitude

Speed below 30 KIAS at altitudes above 500-ft terrain clearance are not recommended due to inadequate pilot visual cues.

(d) Airspeed - Angle of Attack Limits Figure 2

(e) Lateral and Rearward Translation Limits

Lateral	20 knots
Rearward	19 knots

b. <u>Conversion Test Limitations</u>

(1) Conventional to Fan-Mode Conversion (Initial Conditions)

Collective lift setting	25% to 100% demonstrated
Gross weight	10,300 lb maximum demonstrated
Altitude	1000 ft minimum terrain clearance
Airspeed	92 - 105 KIAS (demonstrated)
Horizontal tail incidence	10 deg (Automatic programming)
	-5 deg (Prior to conversion)
Maximum power setting	102% RPM
	700 deg C (10 min) 690 deg C continuous
Minimum power setting	97% RPM (demonstrated)
Thrust spoilers	Retracted
Stability augmentation	On or off
Fan cavity temperature	120 deg C maximum

(2) Fans to Jet-Mode Conversion (Initial Conditions)

Collective lift setting	55% to 100% demonstrated
Angle of attack	+4.5 deg maximum
	-2.0 deg minimum
Bank angle	±30 deg

Sideslip angle	Approximately zero (±2 deg)
Rate of climb	Zero maximum
	-1000 ft/min minimum
Gross weight	10,300 lb maximum
Altitude	1000 ft minimum terrain clearance
Airspeed	84 - 95 KIAS
Horizontal tail incidence	15 deg maximum
	7 deg minimum
Power setting (J-85-5B)	102% RPM maximum
	94% RPM minimum
	700 deg C (10 min) 690 deg C continuous
Wing fan speed	103% RPM maximum
	88% RPM minimum

c. Flight Time and Temperature Limitations

Certain portions of the airframe were subject to high temperatures requiring time and/or temperature limitations for particular flight conditions and configurations until such time as the thermodynamic properties of the aircraft become more fully defined.

(1) Jet-Mode Flight

No limitations except fan-cavity temperatures, as follows:

Maximum continuous	120 deg C
Maximum for 1 min	120 deg - 150 deg C
Overheat conditions	above 150 deg C

(2) Fan-Mode Flight - Fixed Landing Gear with Heat Shields

(a) Hovering Flight (zero - 30 KIAS)

Maximum permissible flight time versus ambient temperature for the zero - 30 KIAS speed regime in close proximity to the ground is presented in Figures 3 to 6.

(b) Transition Flight (above 30 KIAS, OGE)

Indicated vector angle 35 deg and above	6.0 min maximum
Indicated vector angle less than 35 deg	10.0 min maximum
Total FM flight time	10.0 min maximum

(3) Fan-Mode Flight - Retractable Landing Gear

The landing gear was in the retracted position at airspeeds above 60 KIAS or at indicated vector angles greater than 30 deg. A dash acceleration through conversion, however, was permitted with the gear extended when the extension of the gear was accomplished within a maximum of 15 sec.

(a) Landing Gear Extended, Wheel Well Doors Open

Ground operations at 70% RPM	6.0 min maximum
Hovering IGE	2.0 min maximum
Airspeed less than or equal to 60 KIAS and less than 30 deg vector angle, OGE	same as in Item c(2)

(b) Landing Gear Retracted, Wheel Well Doors Closed

Airspeed above 60 KIAS or greater than 30 deg vector angle	4 min maximum

Airspeed less than or equal to 60 KIAS and less than 30-deg vector angle, OGE	same as in Item c(2)

d. Prohibited Maneuvers

Intentional spins, inverted flight, stalls or aerobatics were prohibited because of unwarranted risk and because no significant contributions would be made to the current evaluation of the aircraft.

e. Maneuvering Limitations and Flight Test Experience

(1) Jet-Mode Flight

(a) Normal Load Factor Envelope - Figure 3

(b) Sideslips - Figure 4

Flight test experience of sideslip maneuvers is presented in Figure 4. No known aircraft restriction as such existed; however, the data shown represented near full rudder input or near maximum pilot effort.

(2) Fan-Mode Flight

(a) Structural Design Envelope - Figure 5

(b) Sideslip - Figure 6

Flight test experience of fan-mode sideslips is presented in Figure 6. It is recommended that these values not be exceeded.

f. Takeoff Limitations

(1) Jet-Mode Flight

Maximum gross weight, Phase II flight test policy	11,600 lb
Maximum forward C.G. location	Fuselage Station 240.0
Maximum wind velocity for flight test operations	15 kt (any direction)

Maximum crosswind component	5 kt
Maximum nosewheel lift-off speed	120 kt ground speed

(2) Fan-Mode - Vertical Lift-Off

Maximum gross weight	Figure 7
Maximum forward C.G. location	Fuselage Station 240.0
Maximum wind velocity	5 kt
Maximum crosswind component	zero

The aircraft must be headed into the wind prior to lift-off.

(3) Fan-Mode Flight - Rolling Takeoff (STOL)

Maximum gross weight (Same as FM)	Figure 7
Maximum forward C.G. location	Fuselage Station 240.0
Maximum wind velocity for flight test operations	15 kt

FIGURE No. 1

JET MODE AIRSPEED AND ALTITUDE ENVELOPE

FLAPS AND LANDING GEAR RETRACTED

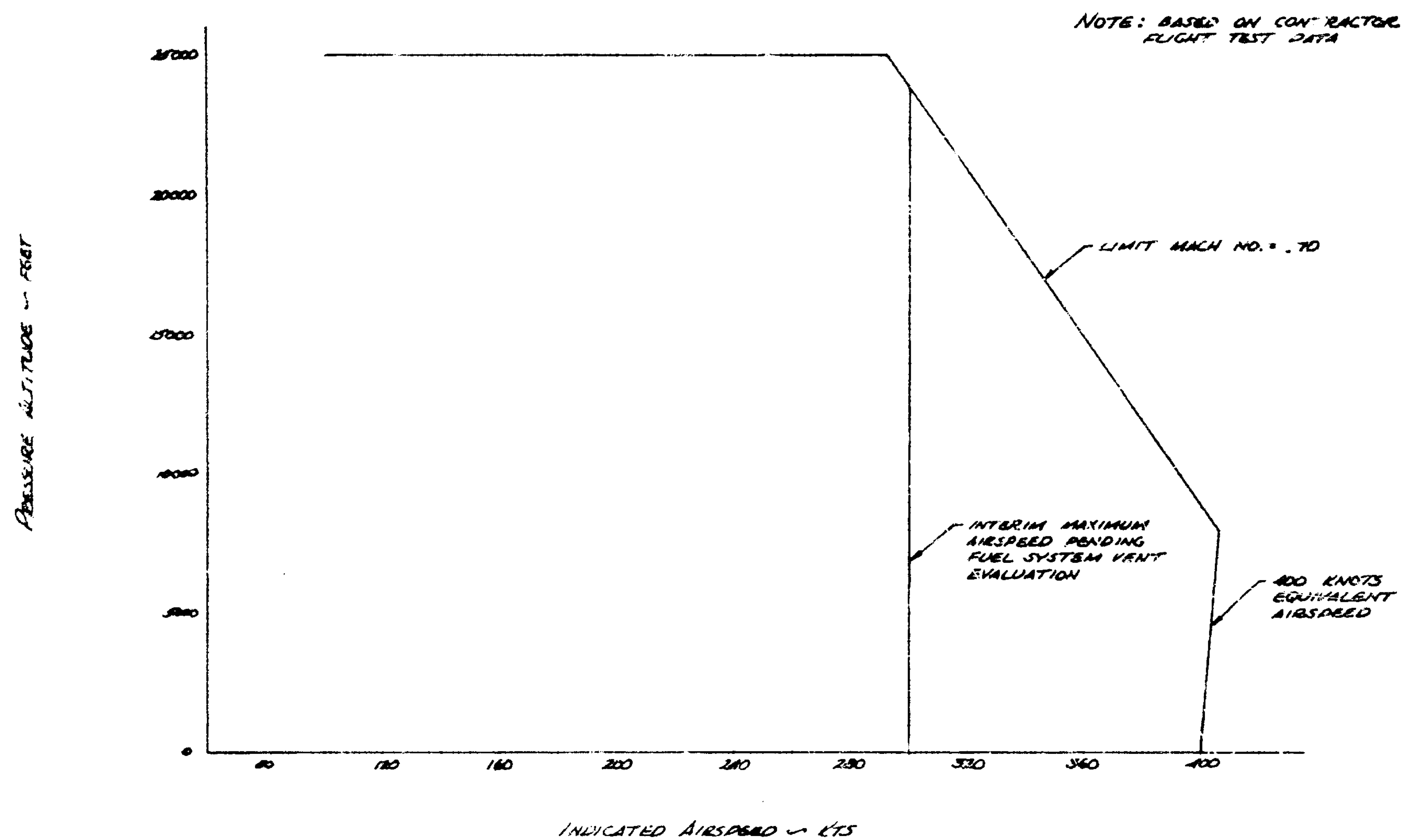


Figure No. 2
FAN MODE AIRSPEED AND ANGLE
OF ATTACK ENVELOPE

DENSITY ALTITUDE = 0-9000 FT.
WING FAN SPEED = 90-103 %

NOTE
BASED ON CONTRACTOR
FLIGHT TEST DATA.

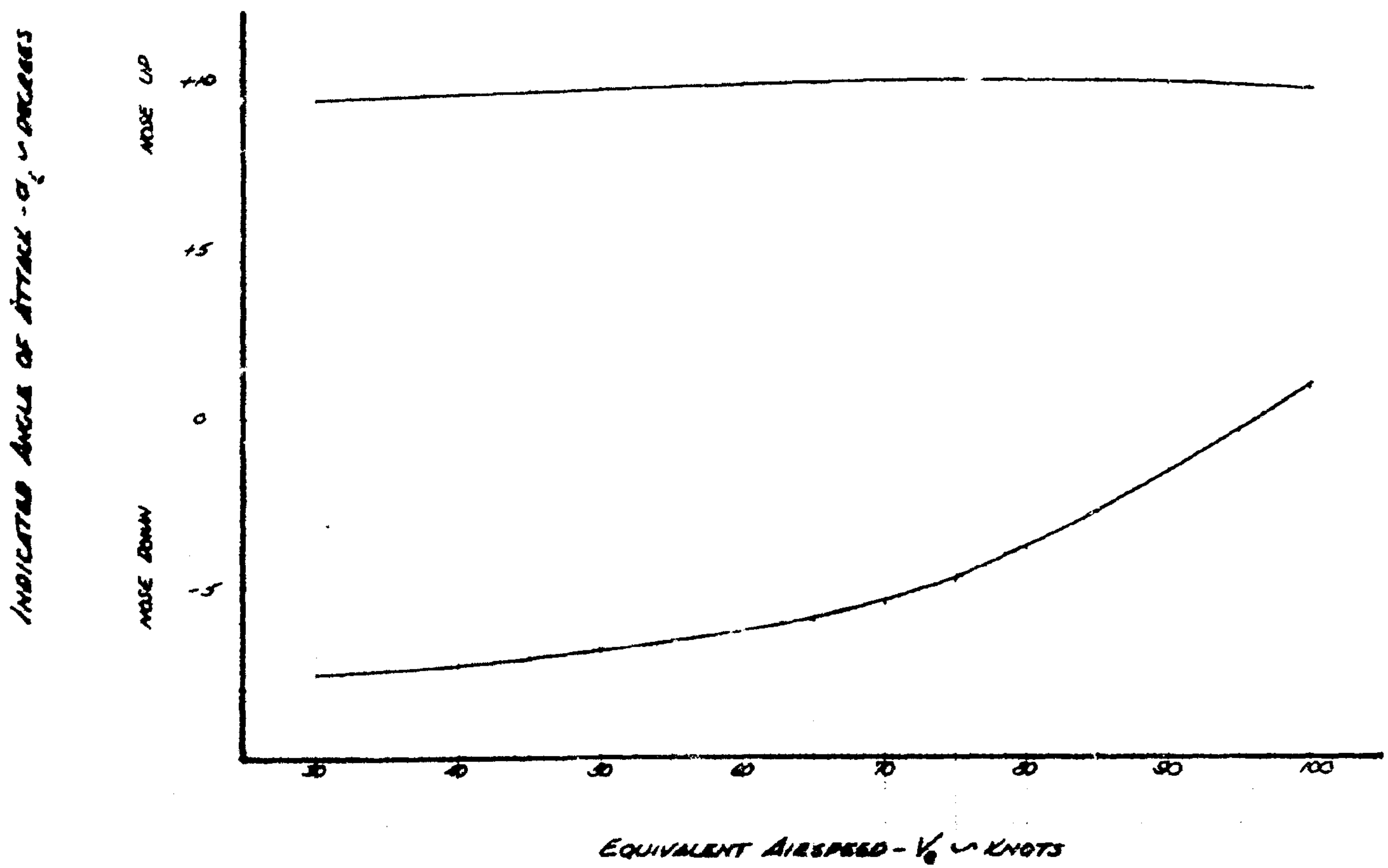


FIGURE No.3
JET MODE STRUCTURAL DESIGN ENVELOPE

GROSS WEIGHT = 9200 POUNDS

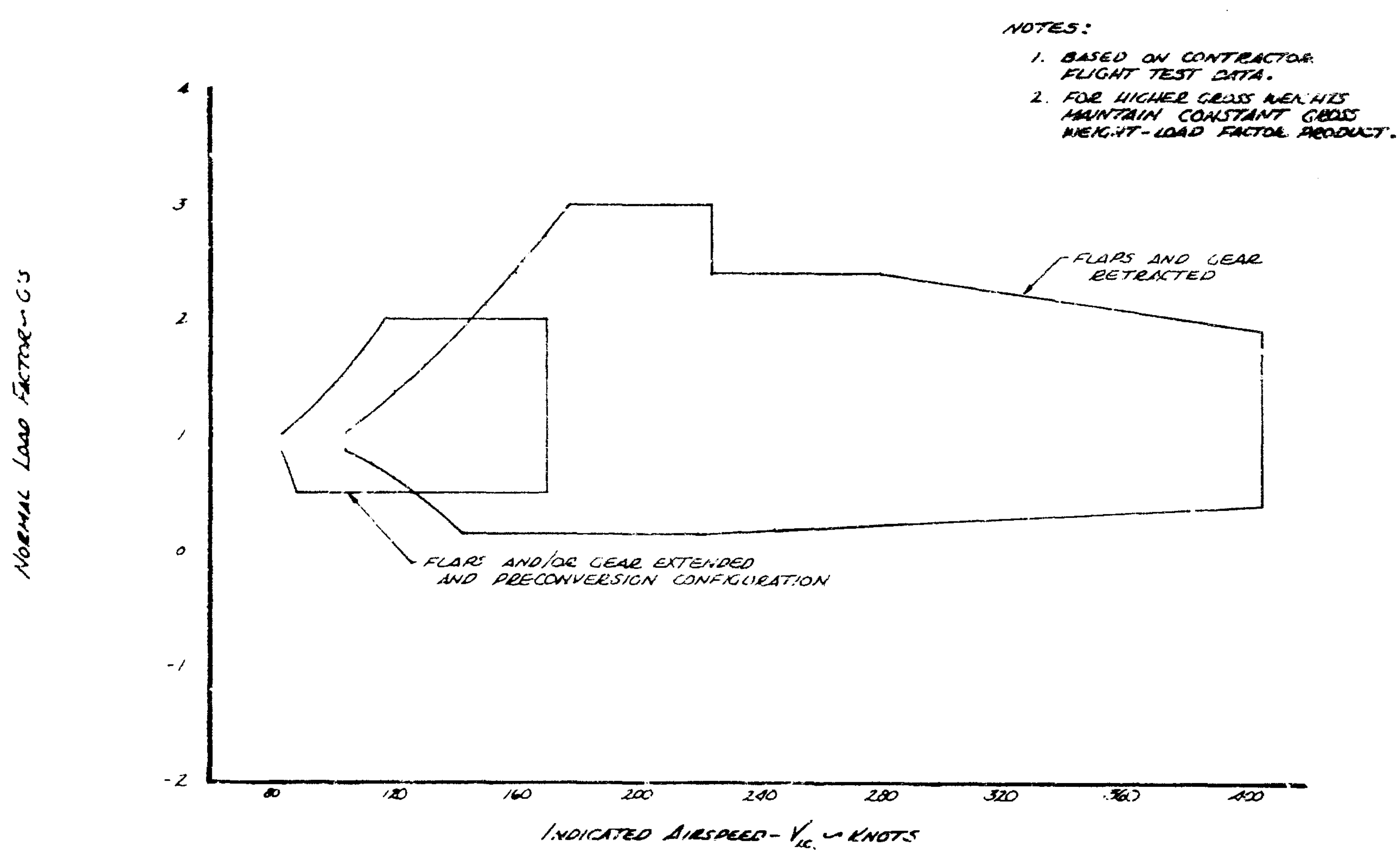


FIGURE No 4
JET MODE SIDESLIP ENVELOPE

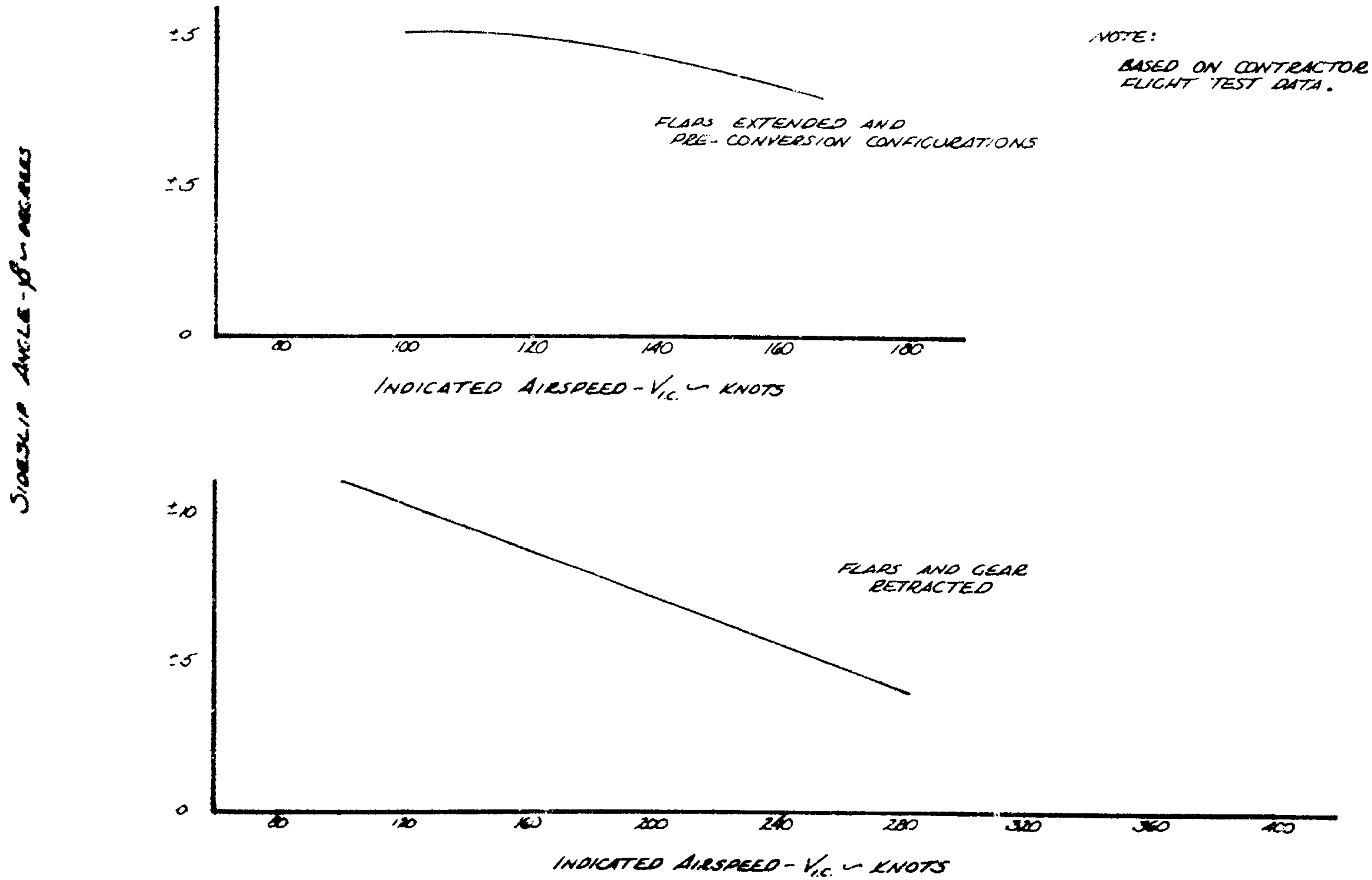
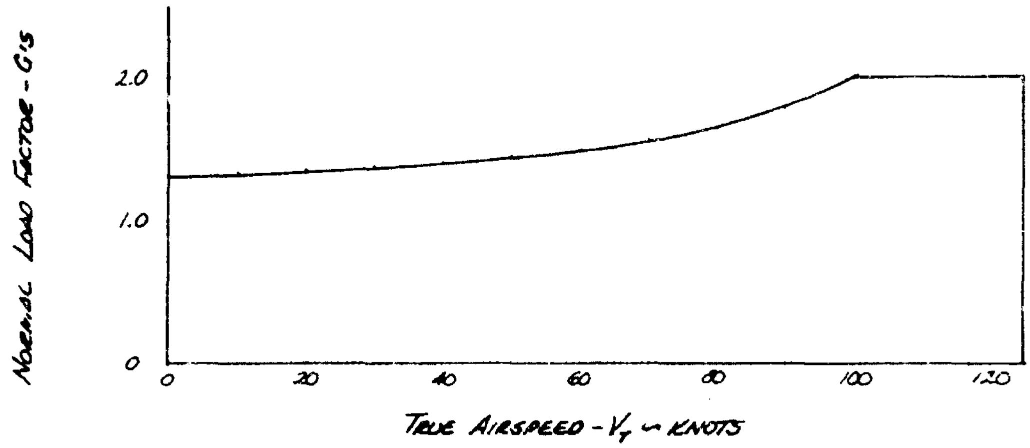


FIGURE NO. 5
FAN MODE STRUCTURAL DESIGN ENVELOPE

GROSS WEIGHT = 9200 POUNDS

NOTE:
1. FOR HIGHER GROSS WEIGHTS MAINTAIN CONSTANT WEIGHT-LOAD FACTOR PRODUCT.



MAXIMUM DESIGN ANGULAR RATES AND ACCELERATIONS

	HOVER (0 TO 30 KTS. TAS)	TRANSITION (30 TO 125 KTS TAS)
PITCH RATE ~ RADIANS/SEC	± 1.0	± 1.0
ROLL RATE ~ RADIANS/SEC	± 1.38	± 1.38
YAW RATE ~ RADIANS/SEC	± 1.31	± 1.31
PITCH ACCEL ~ RADIANS/SEC	± 1.25	± 3.00
ROLL ACCEL ~ RADIANS/SEC	± 1.75	± 2.65
YAW ACCEL ~ RADIANS/SEC	± 1.05	± 1.05

FIGURE No. 6
FAN MODE SIDESLIP ENVELOPE

NOTE:
BASED ON CONTRACTOR FLIGHT TEST DATA.

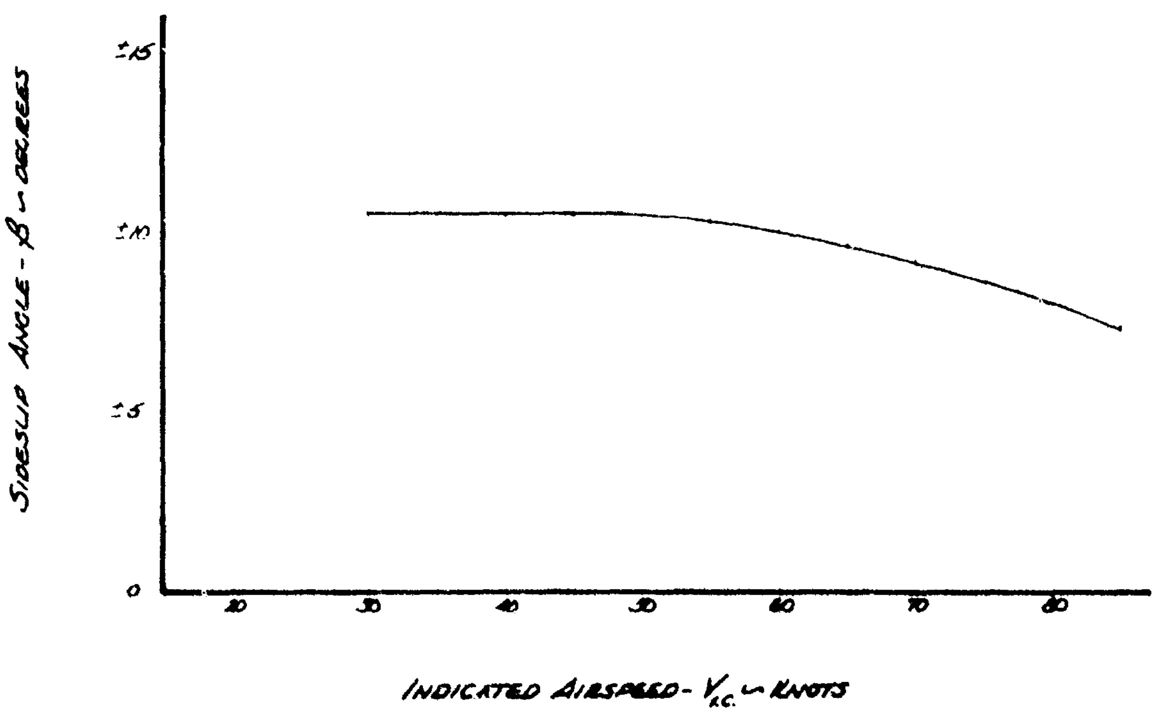
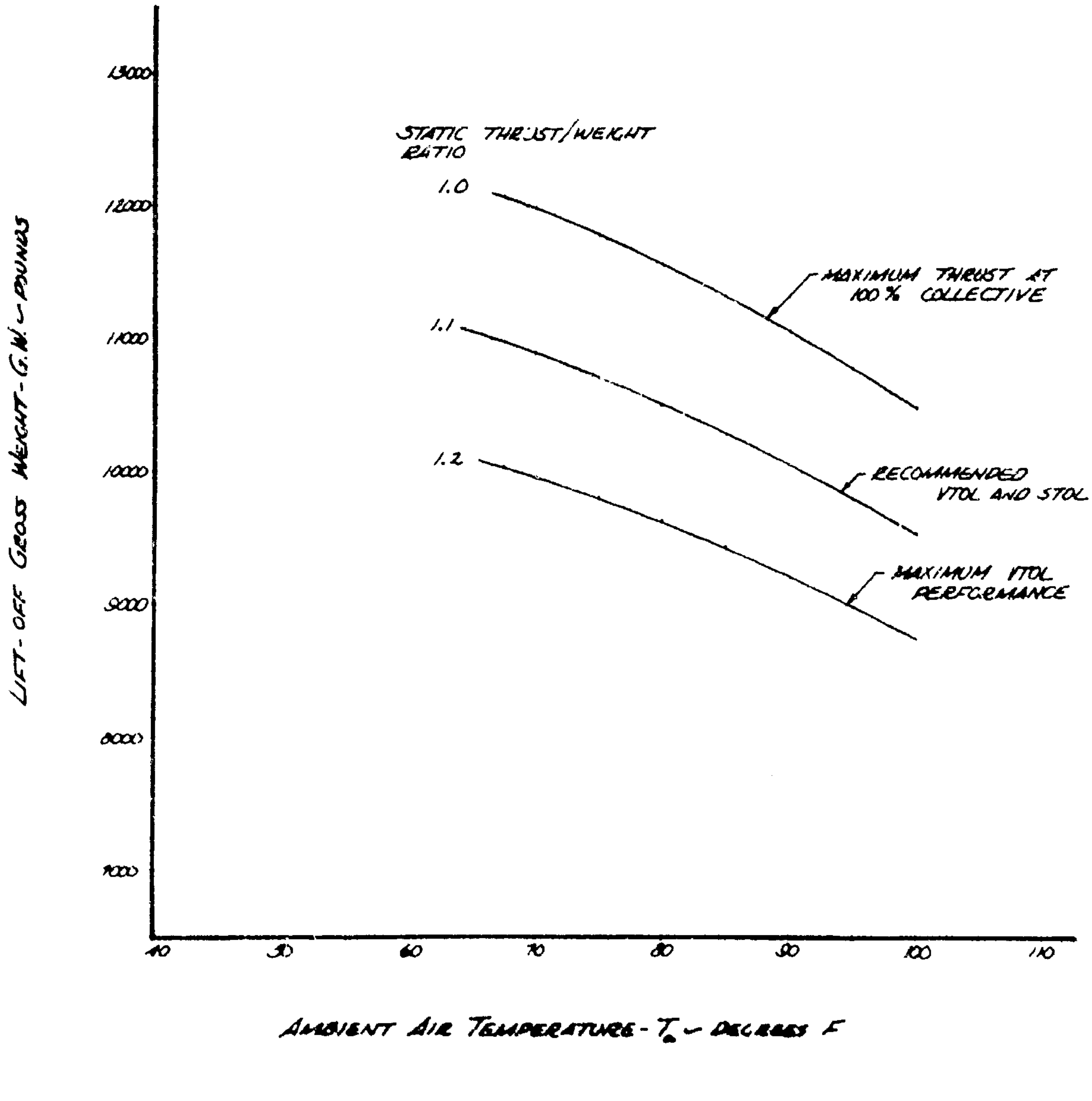


FIGURE NO. 7
FAN MODE TAKE-OFF WEIGHT
VS. AMBIENT TEMPERATURE

PRESSURE ALTITUDE = 2500 FEET

NOTE:
DATA BASED ON CONTRACTOR FLIGHT TEST DATA



APPENDIX V

TEST INSTRUMENTATION

1.0 TEST PARAMETERS

The test instrumentation was supplied, calibrated, installed and maintained by the contractor in accordance with Reference b.

A General Electric (GE) 300A Airborne Automatic Data Acquisition System was used to record flight data parameters. The following parameters were recorded by this system during the stability and control tests of the XV-5A:

a. Angle of Attack

b. Angle of Sideslip

c. Altitude

d. Airspeed (High and Low)

e. Outside Air Temperature

f. Longitudinal Stick Position

g. Longitudinal Stick Force

h. Elevator Position

i. Pitch-Fan Door Position

j. Horizontal Tail Position

k. Pitch Rate

l. Pitch Attitude

m. Lateral Stick Position

n. Lateral Stick Force

o. Right-Wing Aileron Position

p. Left-Wing Aileron Position

q. Roll Rate

r. Roll Attitude

s. Right-Wing Odd-Louver Position

t. Right-Wing Even-Louver Position

u. Left-Wing Odd-Louver Position

v. Left-Wing Even-Louver Position

w. Rudder Pedal Position

x. Rudder Pedal Force

y. Rudder Surface Position

z. Yaw Rate

aa. Yaw Attitude

bb. Collective Control Position

cc. Flap Position

dd. Diverter Valve Position

ee. Wing-Fan Door Position

ff. Beta Vector Command Position

Other parameters were recorded by the data acquisition system but were not considered mandatory for the stability and control portions of the test.

2.0 DATA ACQUISITION SYSTEM

The GE 300A Airborne Automatic Data Acquisition System was a high-speed pulse-code-modulation (PCM) system. It was completely transistorized with a self-contained analog-to-digital conversion and packaged for minimum size and weight.

The GE 300A system was capable of recording from 12 to 90 data channels. The recording of both low- and high-level data sources was possible. These analog signals were multiplexed and converted to a PCM format with parallel output in a form suitable for recording on magnetic tape. The specifications for this system were:

a. Number of Channels	90 channels for data input 10 digital channels
b. Sampling Rate	100 samples/sec/channel
c. Resolution	Ten bits
d. Accuracy	± 0.5% low-level ± 0.2% high-level
e. Recording Time (Maximum)	16 min
f. Tape Speed	30 in/sec
g. Power Requirements	28 volts DC @ 20 amps max
h. Weight	100 lb

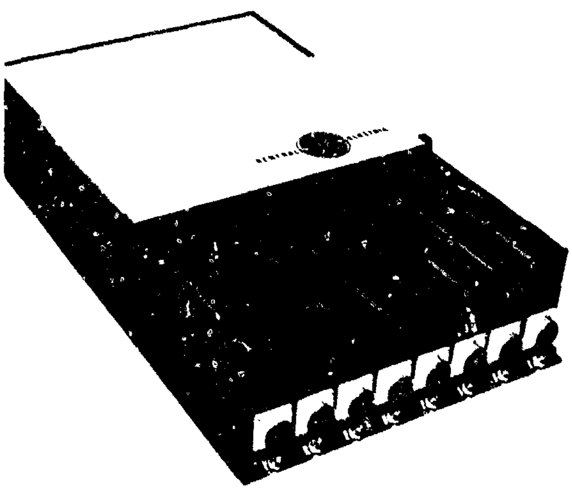


PHOTO 12 - PCM System with Multiplexer Installed

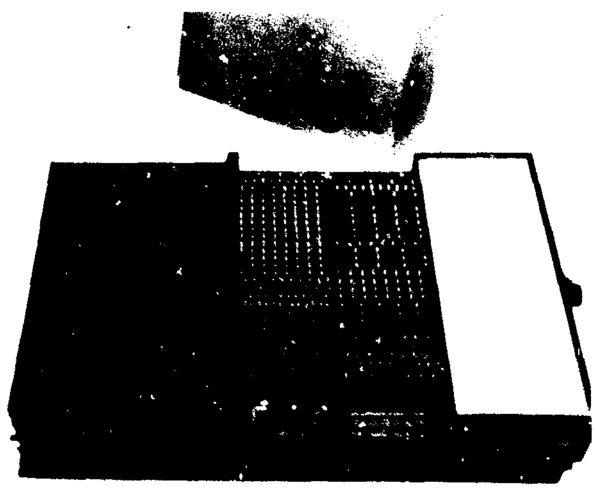


PHOTO 13 - PCM System with Encoder Exposed

When operating properly, the data acquisition system had sufficient accuracy for recording stability and control flight data. A continuous check by highly technical personnel, however, was required to verify the validity of the data. The major problems encountered during the test program were overall system noise, shifting of calibrations, and need of a highly complicated ground station to produce the raw data in engineering units.

This type of data acquisition system was not conducive to operating at locations other than the principal test site, where a ground station and the necessary technical personnel were readily available. This ground station required trained and experienced technical personnel for maintenance, operation, and assurance of reproduction of valid data. The data acquisition system was designed, manufactured, and generally serviced and maintained by the contractor.

The preflight time for the PCM system required approximately four hours. When a dawn flight was scheduled this requirement could be successfully accomplished only by providing the necessary personnel to start the preflight procedures at an early hour.

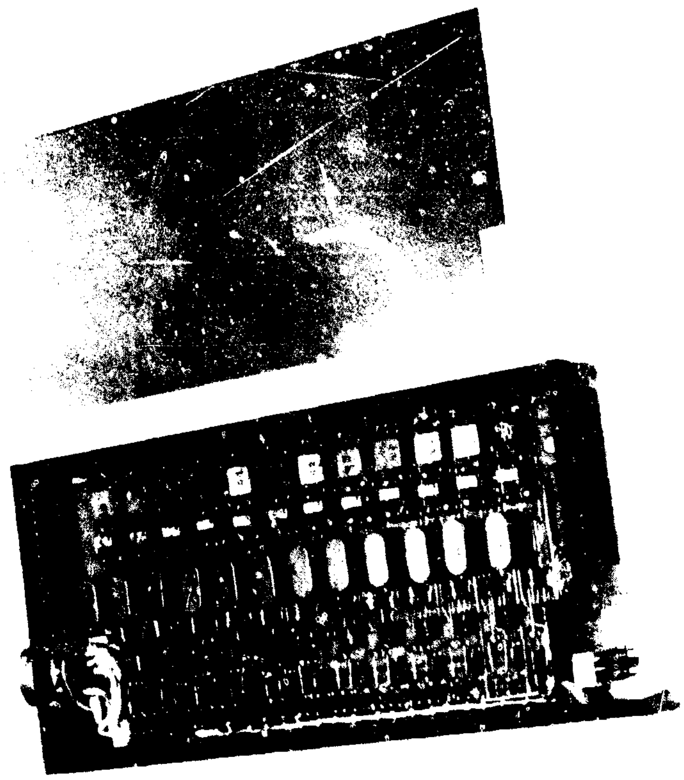


PHOTO 14 - Multiplexer Unit

During the initial portion of the program the calibration and preflight procedures were generally outlined in many cases by verbal instructions. This condition required judgment from the individual performing the operation. The same interpretation and judgment were not reached by different individuals performing the same calibration. This situation resulted in errors, inconsistencies and non-repeatability and contributed to a generally low data-accuracy and confidence level.

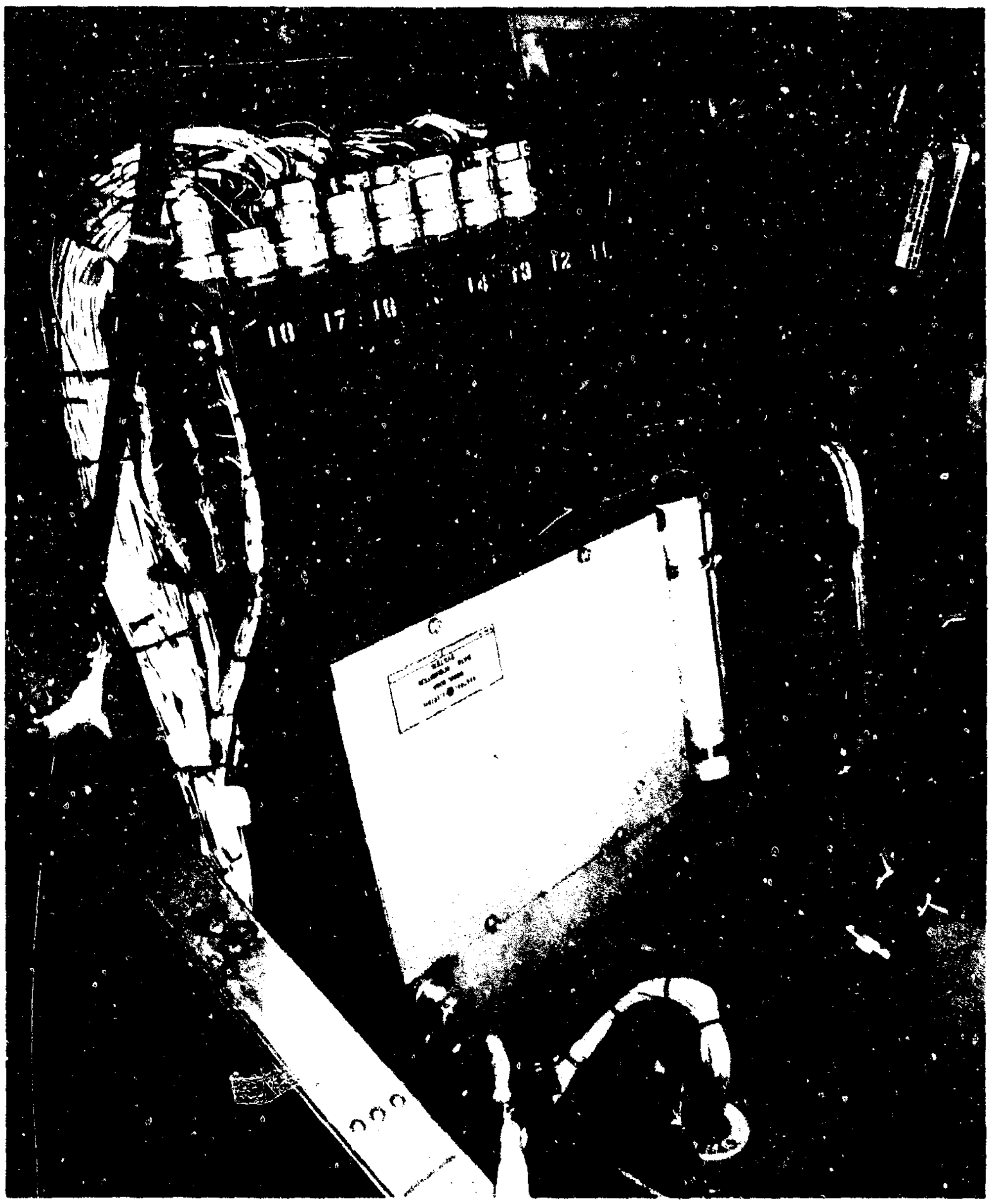


PHOTO 15 - PCM System Installed in Aircraft

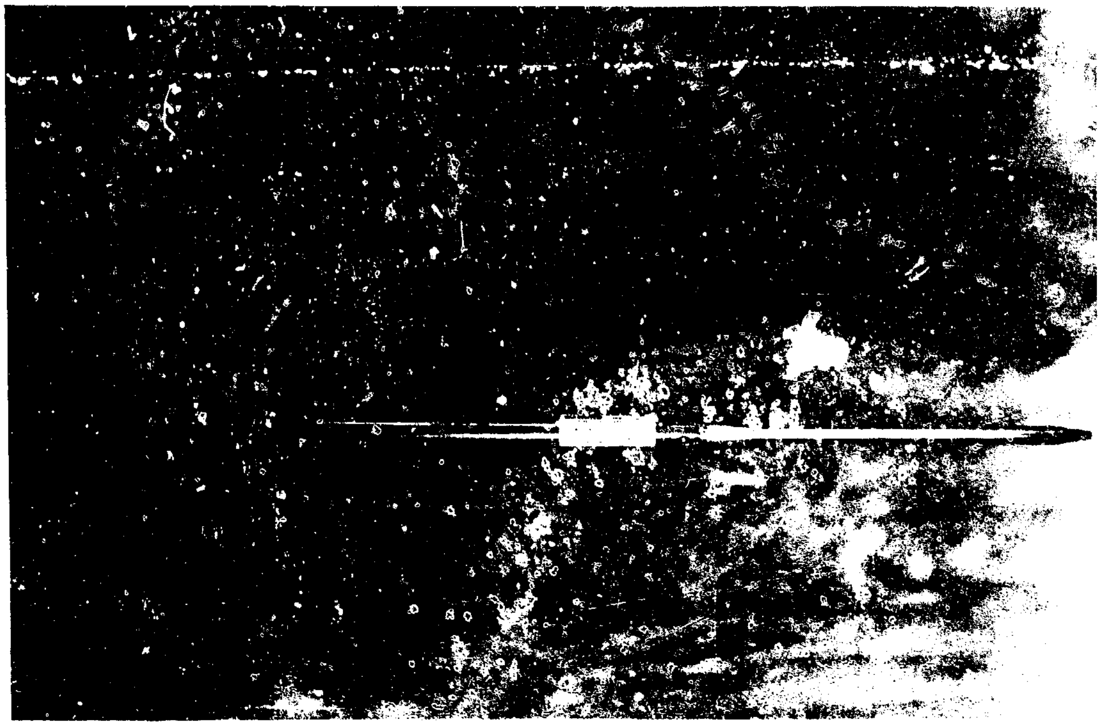


PHOTO 16 - XV-5A Wing Boom, Airspeed

PHOTO 17 - XV-5A Wing Boom OAT

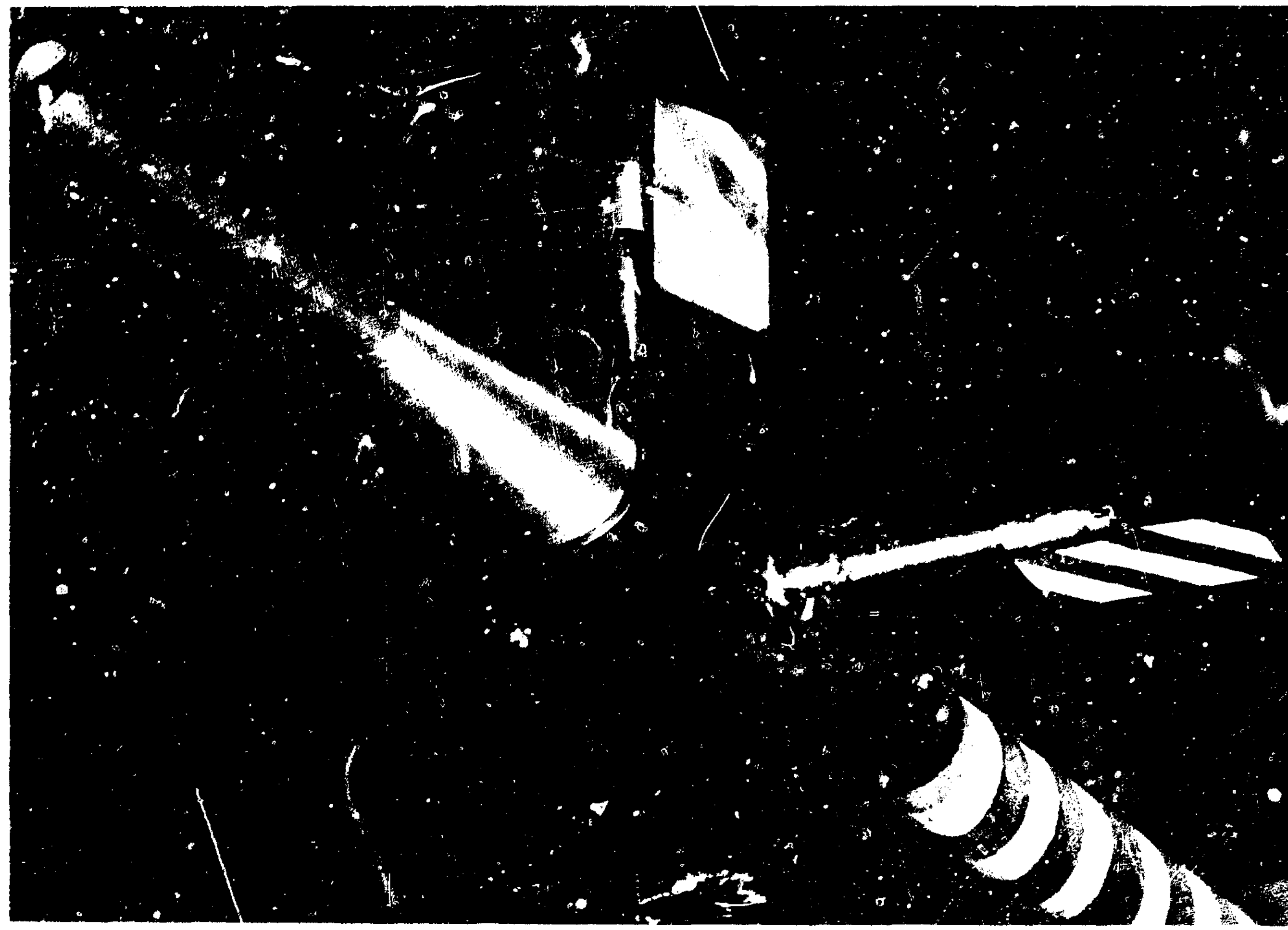


PHOTO 18 - XV-5A Nose Boom; Airspeed, Angle of Attack, Angle of Side Slip

APPENDIX VI

WEIGHT AND BALANCE

The test aircraft, S/N 62-4505, was weighed prior to the flight. The weighing was accomplished on the weight and balance facilities of the U. S. Air Force Flight Test Center (AFFTC), Edwards Air Force Base. The test instrumentation was installed prior to the weighing. The contractor weight data established the weight of the total instrumentation at approximately 500 pounds. The basic weight (empty weight plus trapped oil and fuel) was 8685 pounds and the C.G. was at Station 243. Changing the gear to the locked-down position and installing the heat shield increased the basic weight by 42 pounds.

The fuel system was also calibrated with the AFFTC facilities. Known fuel quantities were added incrementally to the aircraft. Fuel density and volume were established for each fuel increment added to the system. After the fuel level was allowed to stabilize, the quantity indicators were recorded and the aircraft was reweighed. This data was then used to calculate C.G. locations for various fuel loadings. Weight and balance data was also obtained in a similar manner to determine the C.G. change with aircraft attitude and fuel loading.

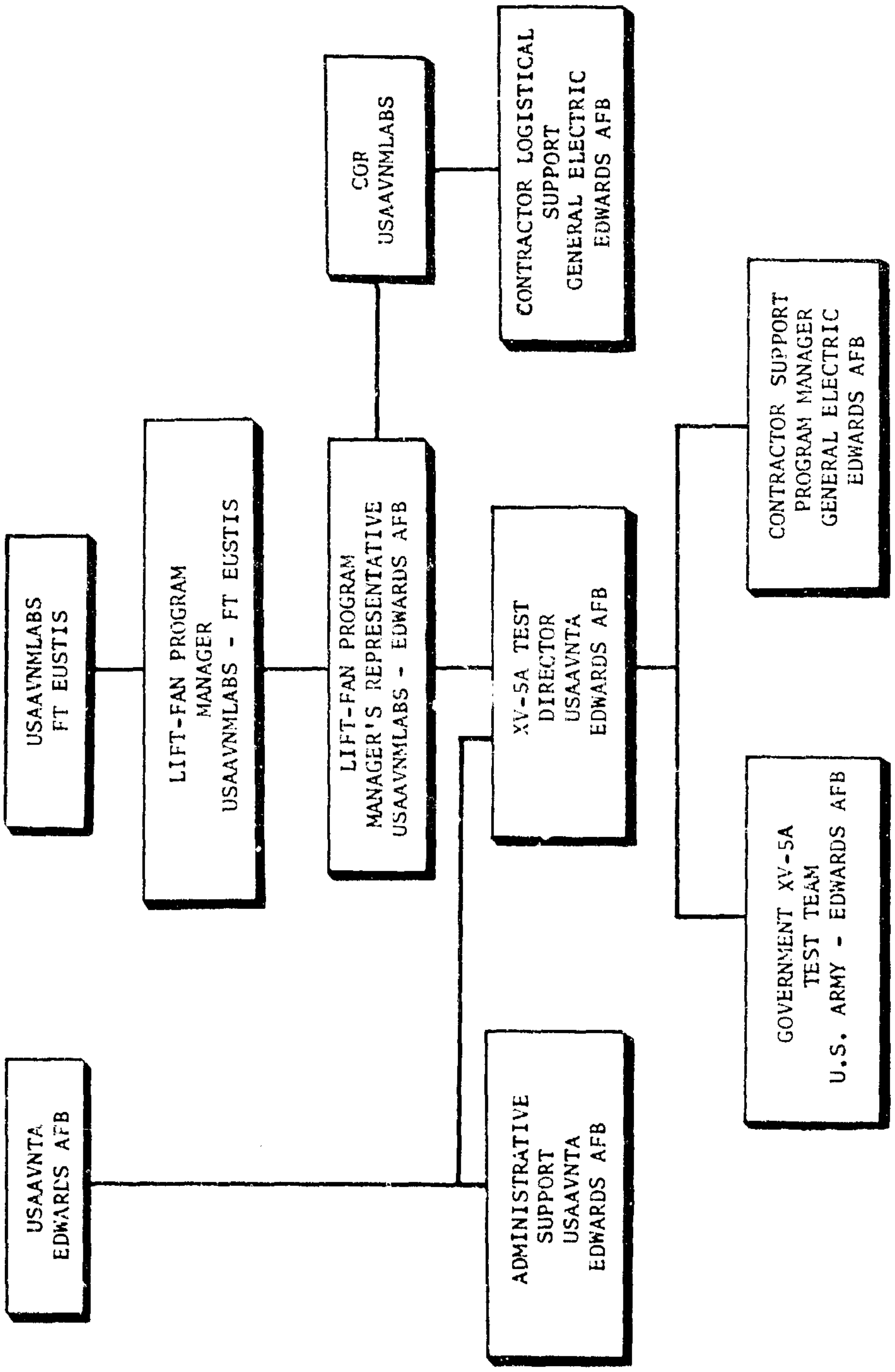
APPENDIX VII

PILOT OPINION RATINGS

ADJECTIVE	DESCRIPTION	RATING
EXCELLENT	Includes optimum	1
VERY GOOD	No unpleasant characteristics; some nuisance-type deficiencies when no impairment to normal operation occurs.	2
GOOD	Some unpleasant characteristics in regimes where no impairment to normal operation occurs.	3
FAIR	Some unpleasant characteristics that cause perceptible fatigue; precision tasks possible after additional training.	4
POOR	Controllable but fatiguing; precision tasks possible but difficult even after extensive training.	5
POOR to BAD	Controllable for short periods only without excessive fatigue; precision tasks questionable even after extensive training.	6
BAD	Total pilot attention required to operate aircraft; precision tasks impossible.	7
DANGEROUS	Almost uncontrollable; accident probable.	8
CATASTROPHIC	No control; accident certain, escape questionable.	9

APPENDIX VIII

DETAILED DESCRIPTION OF XV-5A TEST PROGRAM RESPONSIBILITIES



XV-5A TEST PROGRAM RESPONSIBILITIES

1.0 XV-5A PROGRAM MANAGER'S REPRESENTATIVE AT EDWARDS AIR FORCE BASE (PROVIDED BY USAAVNMLABS)

a. Be responsible to the Lift-Fan Program Manager for conduct of the XV-5A Government Flight Evaluation at Edwards Air Force Base.

b. Provide necessary technical and contractual support to, and coordination with, the XV-5A Test Director.

c. Assure necessary coordination with the contractor and other Government agencies.

d. Recommend contract program changes to the Lift-Fan Program Manager, USAAVNMLABS, for execution.

e. Provide Contracting Officer's Representative (COR) services at the XV-5A test site.

f. Provide briefing on the XV-5A program to certain visitors at the direction of CO, USAAVNMLABS, or at the request of CO, USAAVNTA, or CG, USAFFTC.

2.0 XV-5A TEST DIRECTOR AT EDWARDS AIR FORCE BASE (PROVIDED BY USAAVNTA)

a. Provide technical and administrative direction for the research flight test of the XV-5A.

b. Be responsible to the XV-5A Program Manager's Representative for conduct of the approved XV-5A flight test program.

c. Establish and/or approve flight test operational procedures and monitor their compliance by contractor and Government personnel.

d. Supervise daily flight test activities:

(1) Approve each scheduled flight, including aircraft configuration, pilot selection, flight test card to be flown, alternate test card to be flown, instrumentation, aircraft maintenance, etc.

(2) Supervise instrumentation of the test aircraft; e.g., modification and calibration.

(3) Supervise the collection, reduction, plotting and analysis of flight test data.

e. Recommend aircraft and instrumentation modifications to the XV-5A Program Manager's Representative.

f. Provide the COR information by which to validate charges against the Government under terms of the support contract.

g. Supervise pilot proficiency, general qualification and proficiency in the XV-5A.

3.0 XV-5A TECHNICAL CONSULTANTS AT EDWARDS AIR FORCE BASE (GOVERNMENT AND NON-GOVERNMENT)

a. Be selected on the basis of their ability to contribute to the successful attainment of the established program objectives.

b. Be supplied to the program for varying periods, depending upon their assignment and the type of testing and/or problems encountered, in many cases for the duration of the program.

c. Be assigned as follows: (1) Staff consultants, as assistants to the Test Director to contribute to the assigned phase of the overall test program and (2) Other consultants, as engineering support to one of the two project engineers.

d. Report administratively and technically to the Test Director, if Government consultants.

4.0 CONTRACTOR SUPPORT PROGRAM MANAGER AT EDWARDS AIR FORCE BASE

a. Be responsible to the Test Director for all contractor support supplied to the program.

b. Manage the approved program, including modifications, under the direction of the Test Director.

c. Provide administrative and technical control over non-Government support personnel.

d. Plan, schedule and conduct program planning meetings, review meetings, briefing and debriefing of each test flight.

e. Be responsible to the Test Director for off-site design, test and/or fabrication of aircraft/propulsion system hardware in support of the flight test program.

f. Establish priorities for facilities, equipment, special support shops and personnel.

g. Provide for flight test support, e.g., chase-pace aircraft, emergency equipment, radio frequencies, airspace allocations, tracking and camera facilities, etc.

5.0 LIFT-FAN PROGRAM MANAGER AT USAAVNMLABS, FORT EUSTIS

a. Be responsible to CO, USAAVNMLABS, for the conduct of all Lift-Fan research.

b. Provide technical guidance and contractual support to the XV-5A Government Flight Evaluation.

c. Provide public information services through the Public Information Officer, USAAVNMLABS.

APPENDIX IX

REFERENCES

a. Contract No. DA 44-177-TC-715, "Lift-Fan Flight Research Aircraft Program," U. S. Army Aviation Materiel Laboratories (USAAVNMLABS), 10 November 1961.

b. Contract No. DA 44-177-AMC-54(T), "Support for Army Flight Tests of XV-5A Aircraft," USAAVNMLABS, 28 June 1963.

c. Modification No. 3, Contract No. DA 44-177-AMC-54(T), "Support for Army Flight Tests of XV-5A Aircraft," USAAVNMLABS, 10 February 1965.

d. Modification No. 8, Contract No. DA 44-177-AMC-54(T), "Support for Army Flight Tests of XV-5A Aircraft," USAAVNMLABS, 26 July 1965.

e. Unclassified Message 10-2131, AMCRD, Hq, U. S. Army Materiel Command (USAMC), 20 October 1964, subject: "XV-5A Aircraft 100-Hour Flight Research Program."

f. Plan of Test, USATECOM Project No. 4-5-1220-01, "Engineering Research and Evaluation Test of the XV-5A Lift-Fan Aircraft," U. S. Army Aviation Test Activity (USAAVNTA), December 1964.

g. "Letter Report of Preliminary Pilot Qualitative Evaluation of the XV-5A Research Aircraft," USAAVNTA, 28 October 1965.

h. Report 408A, "Recommendations for V/STOL Handling Qualities," Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organization, October 1964.

i. Report AFFTC-TIH-64-2004, "Stability and Control," U. S. Air Force Aerospace Research Pilot School, revised November 1964 (AD 443699).

j. Military Specification MIL-F-8785(ASG), "Flying Qualities of Piloted Airplanes," 17 April 1959.

k. Military Specification MIL-H-8501A, "General Requirements for Helicopter Flying and Ground Handling Qualities," 7 September 1961.

l. Specification No. 118, "XV-5A Detail Specification," General Electric Company, 17 August 1962.

m. Report No. 153, "XV-5A Full Scale Wind Tunnel Test Report," General Electric Company, December 1964.

n. General Electric XV-5A Datum No. 4, "Some Comments on Reingestion - Ames Wind Tunnel Results," General Electric Company, 1 September 1964.

o. Report No. 62B125A, "XV-5A Detail Aircraft Specification," Ryan Aeronautical Company, 30 December 1964.

p. Principles of Aerodynamics, James H. Dwinnell. McGraw-Hill Book Company, Inc., New York, N. Y., 1949.

q. Aerodynamics of the Helicopter, Alfred Gessow and Garry C. Myers. The MacMillian Company, New York, N. Y., 1952.

r. Elements of Practical Aerodynamics, Bradley Jones. John Wiley and Sons, Inc., New York, N. Y., 1957.

s. Airplane Performance Stability and Control, Courtland D. Perkins and Robert E. Hage. John Wiley and Sons, Inc., New York, N. Y., 1957.

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Aviation Test Activity (USAAVNTA) Edwards Air Force Base, California	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

Engineering Flight Research Evaluation of the XV-5A Lift-Fan Aircraft

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report, 28 January 1965 to 30 June 1965

5. AUTHOR(S) (Last name, first name, initial)

Rodger L. Finnestead & Kenneth R. Ferrell, Project Engineers
William L. Welter, Major, US Army, TC & William A. Anderson, Project Pilots

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 1966	335	19

8a. CONTRACT OR GRANT NO. b. PROJECT NO. RDT&E Project No. 1F131201D161 c. USATECOM Project No. 4-5-1220-01 d. USAAVNTA Project No. 62-72	9a. ORIGINATOR'S REPORT NUMBER(S) N/A 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) N/A

10. AVAILABILITY/LIMITATION NOTICES

U. S. military agencies may obtain copies of this report from DDC. Other qualified users shall request through Hq, U. S. Army Materiel Command, ATTN: AMCRD-D, Washington, D. C.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Aviation Materiel Laboratories Fort Eustis, Virginia

13. ABSTRACT

An engineering flight research evaluation was conducted to investigate the flying qualities and stability and control characteristics of the research model XV-5A lift-fan vertical and short takeoff and landing (V/STOL) aircraft. The flight evaluation was conducted at Edwards Air Force Base, California, by the U. S. Army Aviation Test Activity, under the technical cognizance of the U. S. Army Aviation Materiel Laboratories. Testing consisted of 24.2 productive flight hours and was conducted from 28 January through 30 June 1965. The flying qualities of the XV-5A observed during this evaluation were suitable for accomplishment of its primary mission as a research aircraft. Test results indicated an excellent stability augmentation system and good compatibility between fan-mode and jet-mode control systems. Poor flying qualities were encountered while hovering below a wheel height of 10 feet. Six characteristics were observed for which correction was considered to be mandatory for any follow-on XV-5 aircraft. Correction of 12 additional characteristics was considered to be desirable for follow-on XV-5 aircraft. Nine areas were recommended for consideration during any further development of this configuration and/or concept. An overall pilot opinion rating of 4 was assigned to the flying qualities of the XV-5A aircraft observed during this evaluation.

DD FORM 1 JAN 64 1473

UNCLASSIFIED
Security Classification

UNCLASSIFIED

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
XV-5A Lift-Fan Aircraft Conventional Control System Fan-Powered Control System Vertical Takeoff and Landing (VTOL) Aircraft Short Takeoff and Landing (STOL) Aircraft Conventional Takeoff and Landing Aircraft Engineering Flight Evaluation Stability and Control Test V/STOL Handling Qualities						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through
________________________________."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through
________________________________."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through
________________________________."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, or *(U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.

END